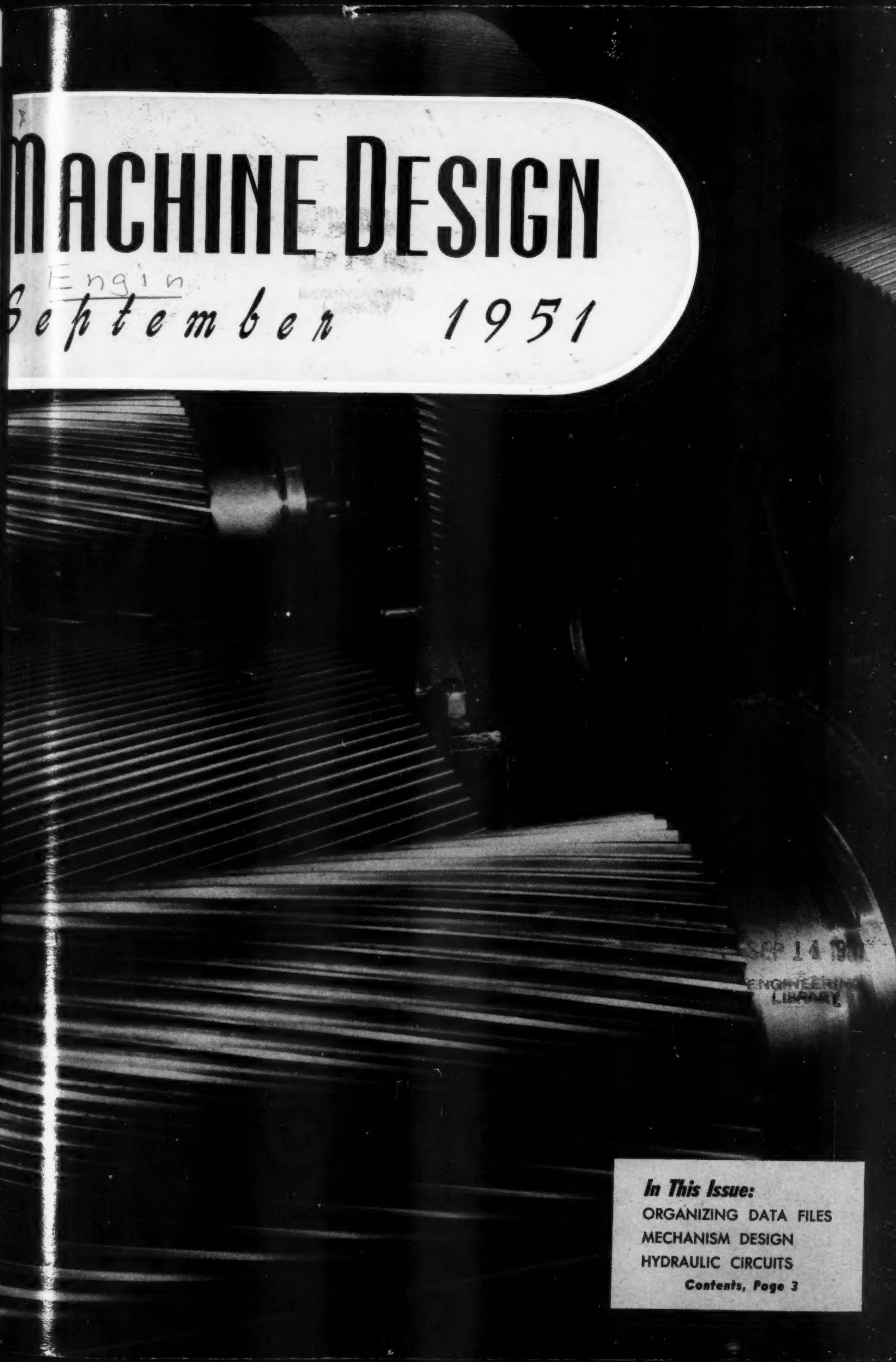
MACHINE DESIGN

Engin

September 1951



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MACHINE DESIGN

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

Vol. 23—No. 9 **September, 1951**

DESIGN FOR PRODUCTION • STYLING • MATERIALS SPECIFICATION • DESIGN ANALYSIS • MACHINE COMPONENTS • ENGINEERING MANAGEMENT

Over the Board

Punched Cards

Those punched cards which we sometimes receive in the mail never fail to arouse our curiosity as to the significance of the oddly placed holes. For a look at one of these IBM cards punched for the complete solution of an engineering problem turn to Professor Kemler's article beginning on Page 148. You will find that you can pick off the numbers at every stage of the calculations, just as the machine does.

Here is an eminently practical, down-to-earth application of modern computing machines which seems to be a far cry from the "giant brains" school of thought. Although there is considerable complexity in the machines there is nothing remotely resembling a thought process. Their only resemblance to a human being is their occasional lapse into carelessness!

This Month's Cover

Shown with the upper half of its gear case removed, this marine propulsion gearing was built by General Electric for the *SS Homer D. Williams,* Great Lakes ore carrier. As an indication of the size of this double-reduction, locked-train unit, the high-speed reduction gears at the right are 45⅜ inches in diameter, the low-speed pinions are 11¼ inches while the bull gear between these pinions is 81½ inches. The turbine propulsion unit, designed to add speed to low-powered carriers, is rated at 3000 shp at 110 rpm.

What Are You Doing?

The percentage of engineering departments working on new and improved designs, and on military and civilian products, is shown in this table:

	Per cent
Redesign of present machines	77.4
New civilian designs	44.4
Military designs	39.3
Redesign for alternate materials	33.6

Evidently many companies are working on more than one of the foregoing categories. The figures are based on your response to a recent MACHINE DESIGN questionnaire asking "Which of these is your design department now working on?" Reminds us of the old saying that a preposition is a bad word to end a sentence with, but anyway we appreciate your co-operation.

Evaluating Engineers

Your requests for extra copies of Randolph Chaffee's "Evaluating Engineers," published in our June issue, have broken all records. They have exceeded our expectations to such an extent that we have had to print extra copies to meet the demand. Your patience in the face of the slight delay in mailing your copies is much appreciated.

Double-Curvature Ball Bearings

Sometimes an article comes into our office "over the transom," as it were, dealing with something we never knew existed. For instance, we didn't know that there was such a thing as a double-curvature ball bearing until Roy Krouse sent us the manuscript which appeared as an article in our February issue. Our judgment in publishing the article is confirmed by the high number of requests for extra copies. But, still intrigued by the subject, we have continued to inquire about the application of such bearings. Double or offset-curvature bearings are used chiefly in aircraft engines. Application data being restricted, we cannot at this time enlighten you further but we shall keep you informed as soon as information can be released.

Coming Next Month

In recent years the October issue of MACHINE DESIGN has featured a Directory of Materials listing hundreds of tradenamed materials used in engineering design, together with significant data on properties and application. This year we are taking a different approach, one which we hope will be better adapted to quick reading yet will have permanent reference value.

A special staff-written section devoted to the theme "designing with modern materials" will contain a comprehensive roundup of the latest information on materials developments. In this presentation we have enlisted the co-operation of leading producers across the nation. They have given generously of their time and knowledge to help us make the section of outstanding value to you. In addition there will be the usual quota of contributed articles and regular departments.

ITEMIZED INDEX

Classified for convenience when studying specific design problems

Design—General

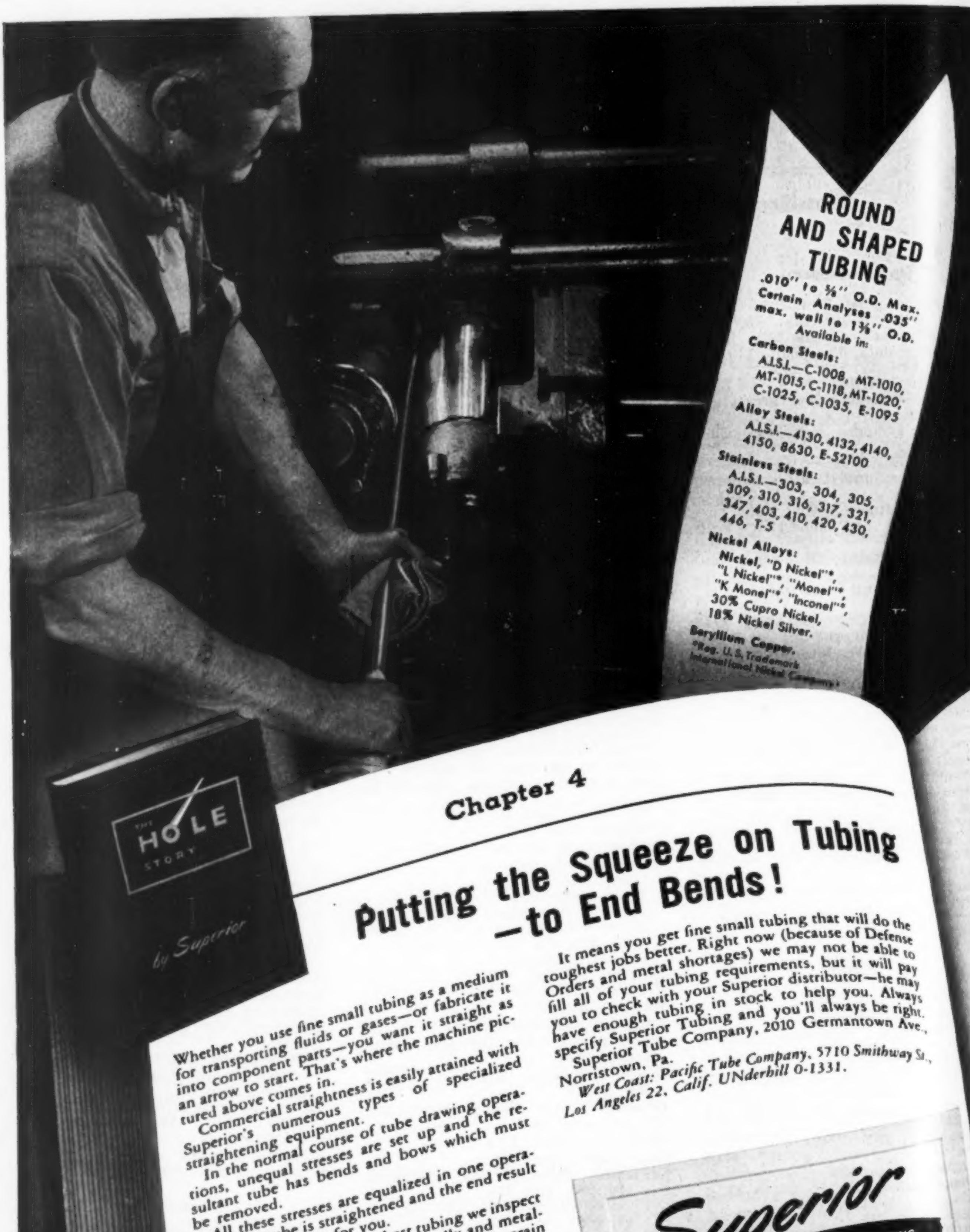
Engineering Department

Materials

Parts

Production

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries generally.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by Superior
Chapter 4
Putting the Squeeze on Tubing —to End Bends!
Whether you use fine small tubing as a medium for transporting fluids or gases—or fabricate it into component parts—you want it straight as an arrow to start. That's where the machine pictured above comes in.
Commercial straightness is easily attained with Superior's numerous types of specialized straightening equipment.
In the normal course of tube drawing operations, unequal stresses are set up and the resultant tube has bends and bows which must be removed.
All these stresses are equalized in one operation. The tube is straightened and the end result is a better product for you.
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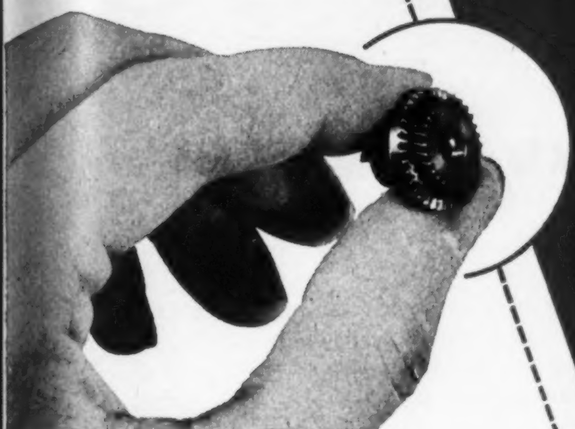

Involute Gear-Tooth Advantages in Angular Drives

A Face Gear with spur or helical teeth, driving or being driven by a gear or pinion, offers decided advantage for transmitting motion through shafts at 90 degrees or other angular settings.

Now, with a standardized FACE GEAR FIXTURE used on the 3-inch Fine-Pitch Gear Shaper, the following advantages of face gears can also be utilized for small-size units:

- **More compact design**
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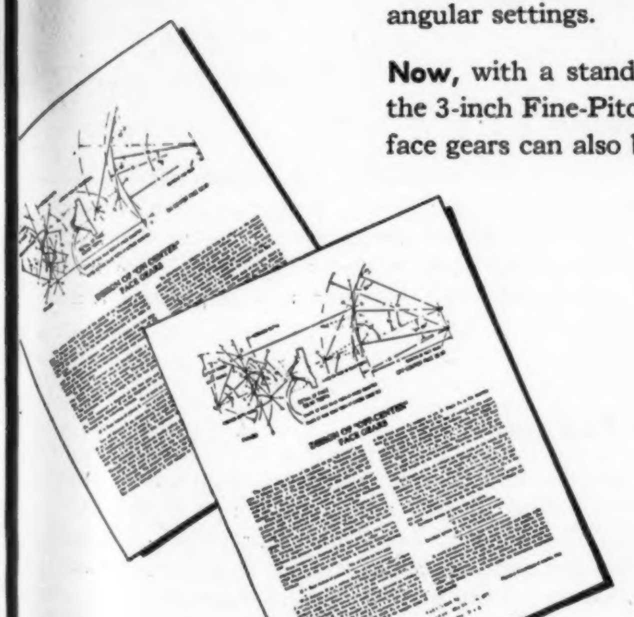
- **Ratios from 3 to 1 and up**
- **Capacity for high speed**
- **Opportunity for reversal of rotation**
- **Ease and economy of manufacture**

A special bulletin on the principles and practical applications of face gears is available on request. Write the nearest Fellows office.



These New DATA SHEETS

explain a simplified procedure for determining the active face width for "on-center" and "off-center" face gears. Copies available.

Fellows

THE FELLOWS GEAR SHAPER COMPANY

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EAR SHAPERS • SHAVING MACHINES • CUTTERS AND SHAVING TOOLS • GEAR NSPECTION INSTRUMENTS • THREAD GENERATORS • PLASTICS MOLDING MACHINES

Today's TOPICS

...IN ENGINEERING AND RESEARCH

Canned Bearings Stay Fresh

In order to resist the damaging effect of moisture, salt water and dirt, replacement bearings for the armed forces may soon be packaged in metal cans. Pilot lines have been set up at the Timken Roller Bearing Co., and it is believed that bearings can be stored under the worst conditions for ten years without deterioration.

Cuts Titanium Metal Cost 80 Per Cent

A new process for producing titanium sponge metal is expected to reduce the present $5-a-pound cost by 80 per cent. Pilot-plant operation at Horizons Inc. is expected to lead to extensive military and civilian use of the light, strong-as-steel metal.

White Brass Replaces Nickel as Plating Base

A white brass, for use as a base in chrome plating, may replace strategically short nickel. The customary procedure is to deposit a nickel-copper base on decorative metal parts before chrome plating. In the Du Pont process, a base of 80/20 zinc-copper alloy is electrodeposited. The final plating is claimed to be indistinguishable in color and brightness from that produced by present methods.

Sponge Rubber Strengthens Hollow Propeller

Light as a feather and bone-hard, a foamed rubber-phenolic-nylon compound is used to strengthen hollow four-bladed propellers at United Aircraft Corp. The compound fills the void between the propeller core and outer shell, preventing vibration and supporting the shell against the impact of rocks and ice thrown up by the plane's undercarriage.

Overloading Gears Softens Metal

Heavy-duty gears go through a metallurgical phase change when overloaded, according to Michigan Tool Co. engineers. Local surface temperatures get high enough to break down the hard heat-treated bronze to a softer structure, causing an increase in the coefficient of friction and reduction in efficiency.

Window "Opens" with Atom-Bomb Blast

Designed to prevent flying glass and minimize explosion damage, a new laminated window developed by Pittsburgh Plate Glass "opens" under pressure. The outer layer of the window is a solid sheet of glass, the

middle layer a partially-segmented sheet of plastic, and the inner layer consists of four triangular-shaped glass pieces. The window will stretch up to 400 per cent of its length without breaking, but if rupture occurs, the four segments open like doors, hinged on the flexible plastic middle layer.

Resistance Thermometers Detect Hydrogen

Using miniature, glass-covered resistance thermometers as active elements of a combination thermal-conductivity bridge, a submarine hydrogen detector developed by the Navy has high stability and accuracy. The detector is not affected by roll, pitch or schnorkel operation, which sometimes causes rapid variations in atmospheric pressure.

Shaver Heads Cleaned Ultrasonically

Oil, grease, metal shavings and lapping compound are removed from small openings in Schick electric shaver heads by sound energy transmitted through a cleaning solvent. It is claimed that the new production operation, which uses a G-E generator, does a better, faster job than brushing.

...IN GOVERNMENT AND INDUSTRY

Less Use of Cobalt Steels Urged

Since cobalt is likely to be in short supply due to expanding jet-engine production, the NPA has recommended that minimum amounts be used in alloying steel. The short-supply situation is also true of nickel, tungsten and molybdenum, although the tungsten supply is expected to ease somewhat for the fourth quarter. Vanadium, chromium and manganese are still tight, but adequate. Boron-treated steels have been suggested as substitutes.

Committee to Study Technical Personnel Situation

Fourteen people from government and industry will serve on the Committee on Specialized Personnel, appointed to make recommendations to the Defense Mobilization Director on the most effective training and use of the nation's scientists and technical personnel. Biggest unfilled demand in industry is for mechanical and electrical engineers and draftsmen. Over sixty occupations are now listed as critical by the Department of Labor.

Nation's Stockpile One-Third Complete

Total value of materials on hand in the nation's stockpiling program is now reported as $3 billion. Although the ultimate goal is $8.3 billion, recent buying has been somewhat slower, due to shortages and competition. A new Government agency, the Defense Materials Procurement Agency, will handle buying and will develop supply-expansion programs.

Unfilled Backlogs Grow

Gear manufacturers now have unfilled order backlogs of six to nine months, with defense-rated orders representing 50 per cent of the total. A similar situation is reported by industrial truck manufacturers, whose unfilled orders now total about 23,000 units, with 50 to 85 per cent rated.

MACHINE DESIGN
A PENTON PUBLICATION

A Neglected Design Tool

EXPERIENCE is the most sought-after qualification a design engineer can possess. Yet the experience of any one man, or even of a group of men comprising an engineering organization, is insignificant alongside the vast storehouse of scientific and engineering knowledge that has been accumulated up to the present. Fortunately the published works of the great authorities of the past and present are available to help us supplement our own meager experience.

Evidence is abundant, however, that too many engineers either scorn the use of books and periodicals in their work or feel that they cannot afford the time to study available publications. Instead they depend on their own resources in developing a design when often a quick review of the published findings of others might have saved untold time and effort.

To neglect so obvious an aid to the solution of engineering problems is just plain inefficient. The answer lies in a positive program for improving the efficiency of engineering effort through the use of published information. Engineering management can take several steps toward this goal.

A well-stocked engineering library should be established and maintained under the supervision of a competent librarian.

Current technical periodicals pertinent to the work of the engineering department should be properly routed to the design engineers who can make best use of them.

An adequate file of data in the form of catalogs, bulletins, reprints, etc., which defy the ordinary rules of library cataloging should be established and maintained as suggested by A. F. Gagne in this issue.

To make the plan effective, engineering management must encourage design engineers to consider the use of published information as an essential part of engineering procedure—a valuable design tool.

Designers should be concentrating on the new untried ideas rather than those that somebody else might have tried before. Conservation of engineering time and effort through effective use of the experience of others will release time for creative effort, resulting in better all-round designs.

Colin Carmichael

EDITOR

Organizing an Engineering Data Fi

. . . for maximum utility in solving design problems

By A. F. Gagne Jr.
Mechanical Development Engineer
Stratford, Conn.

OFTEN the inability to locate specific engineering information causes waste and duplication in the design department—loss of time and money that could be saved if an adequate data file were available.

Source material, such as a magazine article or manufacturer's bulletin, seems to have the peculiar ability to disappear just when needed most to help answer a tough design problem. The best insurance against loss of valuable data like this, and the best way of supplying helpful information is an adequate, up-to-date reference file system.

If the design problem currently being considered is a major one, a data file may not be necessary, since extensive research can be undertaken to locate the answer. But smaller parts or devices do not warrant the effort, with the result that many components often are specially developed and manufactured when satisfactory equipment could be purchased—if the designer only knew where to look.

Of course a certain amount of engineering data containing answers to these semi-routine problems is usually right at hand. Thus, in addition to the usual blueprint and correspondence files, every design office has a miscellaneous assortment of reference texts and mill-supply catalogs. Often there is a more or less hodge-podge collection of manufacturers' bulletins, and each man has usually gathered a few catalogs for his personal use. Finally, there may be a stack of back-number magazines, often bound and filed with their annual indexes. This is a step forward in making magazine information more readily available, but no answer.

Recognizing the inadequacy of this haphazard arrangement, supervision may try to find a solution by building up the departmental catalog collection to the point where it occupies a number of drawers or shelves. In order to achieve some system, the material is often classified alphabetically by manufacturer's name. This is a common arrangement in purchasing departments, and for his requirements the purchasing agent finds it fast and useful. For the

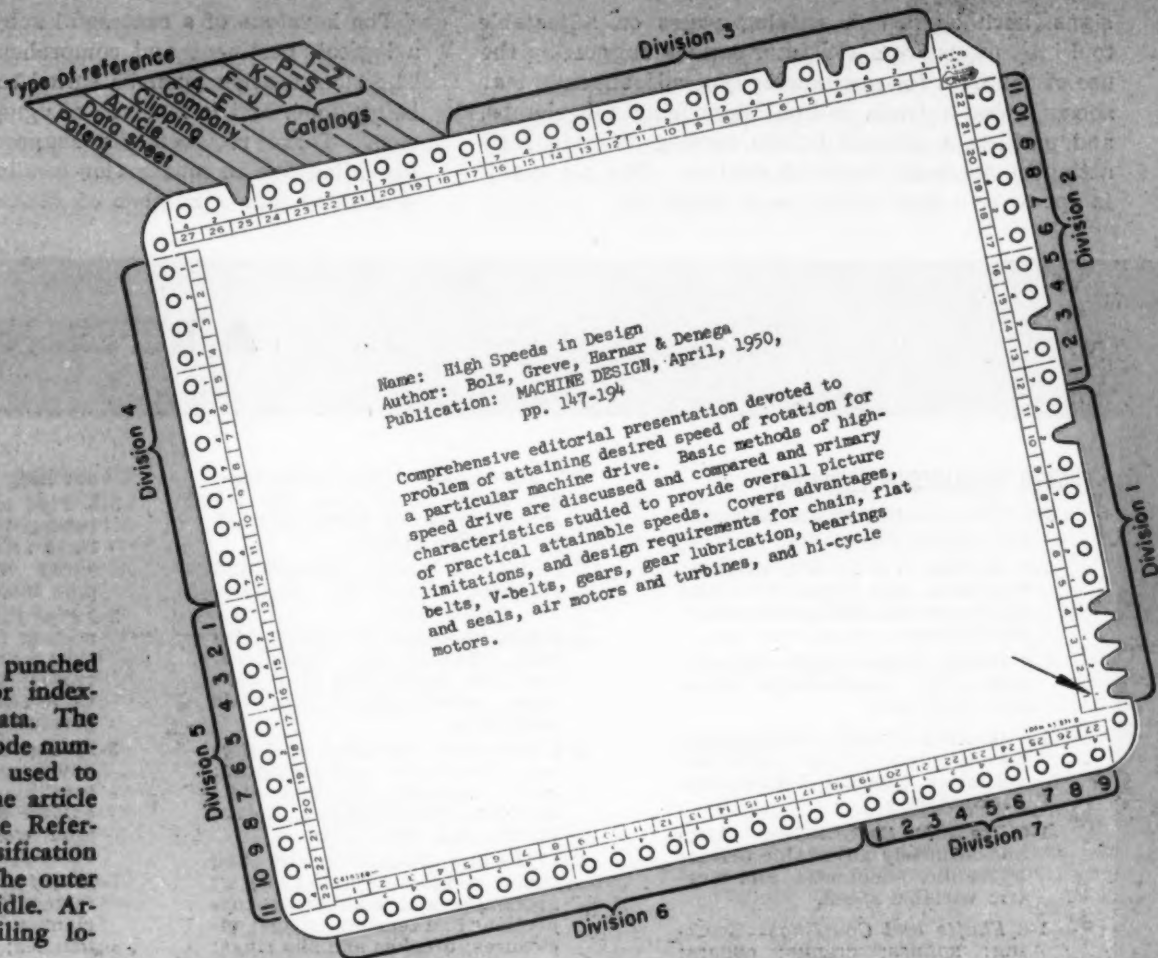


Fig. 1 — Stock punched card suitable for indexing technical data. The inner "direct" code numbers have been used to index a magazine article according to the Reference Data Classification System given. The outer "field" row is idle. Arrow indicates filing location

Card, courtesy McBee Co.

design department, however, the alphabetical arrangement is considered wholly inadequate unless a complete subject cross-index is maintained to help the casual searcher find the names of various concerns manufacturing equipment desired. If the cross-index is prepared by engineering personnel and cost is no objection, then an alphabetical name file may be very satisfactory for catalogs. It is not too well suited to the filing of technical articles and miscellaneous data.

A second system, alphabetical classification by subject, has been used for both catalog and data filing because it is direct and eliminates the need for an index chart or card file. This method relies on pertinent or "catch" words for classification, and thus the file tends to get out of hand as years pass and librarians change. It also requires extensive use of cross-reference sheets in individual files.

A third, inexpensive and effective solution to the objections previously discussed is found in grouping by subject. Material to be filed is classified from a systematic subject-outline chart. This skeleton outline covers all subjects of interest to a designer, and groups related subjects together according to major and minor divisions. Thus, a designer seeking a given type of equipment, an adjustable-speed drive for instance, looks under *Power Transmission Equipment, Variable Speed* and finds at his disposal a whole series of bulletins on different commercial types—variable-pitch pulleys, adjustable-speed motors, gear shifts and so forth, from which he can choose the one best fitted to the application.

The usefulness of the subject file is enhanced by the fact that together with the catalogs are filed relevant data sheets, articles, and "idea" advertisements clipped from trade journals, also technical papers, patents, blueprints, company reports, copies of letters—any and all potentially useful material.

It should be noted that all material pertaining to a given problem is contained in one, two, or at most three folders. It is not necessary to go from one folder to the next as directed by an index-card system. For these reasons, subject filing has been found tremendously helpful in attacking design questions.[1, 2, 3, 4] For example, if a part is to be made adjustable or replaceable, then reference to a file on adjustments will show all manner of successful de-

[1] References are tabulated at end of article.

signs, such as ads or catalog pages on adjustable tool bits, pages from a counter catalog suggesting the use of counters for micrometer-type adjustments, tear sheets from a trade journal describing gib clamps, and perhaps a jig and fixture catalog showing fast-acting commercial clamping devices. The net result is apt to be a faster, lower-cost design job.

The keystone of a successful subject-grouped file is a logical, pertinent and comprehensive classification. The classification must be suited to the type of work being done, and it must be designed for easy expansion. These requirements suggest an arrangement providing five to nine major headings, each of which is divided into a number of subheadings. The sub-

A REFERENCE DATA

POWER TRANSMISSION EQUIPMENT

1-1 *General*—Design comparisons; mill supply catalogs.

1-2 *Belting*—V-belts and sheaves; flat belts and tapes; wire and fiber rope and fittings; tensioning devices.

1-3 *Chain*—Roller, silent, and miscellaneous transmission chain and sprockets.

1-4 *Gearing*—Design; stock gears; speed reducers; and motorized actuators. (See 2-1, 2-3 for more gearmotors.).

1-5 *Variable Speed*—Gear shifts and infinitely adjustable drives; hydraulic, pneumatic, and electric variable speed.

1-6 *Shafts and Couplings*—Shafting; splines; cranks; collars; flywheels; solid and flexible couplings; universal joints; push-pull connections; flexible shafting.

1-7 *Clutches and Brakes*—Jaw and friction disconnect, centrifugal, slip and fluid clutches; overload protection; one-way, single-revolution, pneumatic, and electric clutches; brakes and brake motors (see also 2-1, 2-3); friction materials.

1-8 *Miscellaneous Kinematic Elements*—Cams; screws; indexes; intermittent motions; linkages; counterbalancing; trips; stops; interlocks; servos and computing mechanisms; kinematics.

1-9 *Hydraulics*—Circuits, piping, and fluids; pumps; accumulators; boosters; tanks; cylinders; hydraulic presses; rotary motors; valves and strainers (see also 3-9); maintenance.

1-10 *Pneumatics*—Circuits and pressures; cylinders and speed control; rotary motors and turbines (see 4-7 for air tools); valves and strainers (see also 3-9); lubricators (see also 3-4); mufflers; maintenance.

ELECTRICAL EQUIPMENT

2-1 *Miscellaneous*—General supply catalogs.

2-2 *Power Supply*—Batteries; generators; MG sets; rectifiers; transformers; voltage controllers; saturable reactors; fuses; switchgear; instruments.

2-3 *Motors*—D-c; a-c multiphase and single phase (see also 1-4 and 1-7); motor bases (see 1-5 for variable speed).

2-4 *Motor Controls*—Manual and magnetic; plugging switches and pushbuttons.

2-5 *Miscellaneous Electrical Controls*—Resistors; capacitors; magnets; timers and cycle controls; small relays; magnetic amplifiers.

2-6 *Solenoids, Switches and Signals*—Solenoids and thrustors; limit, mercury, and manual switches; photoswitches; horns; buzzers and pilot lights.

2-7 *Wiring*—Standard wire and cable; conductive coatings; grommets and insulation; connections and terminal strips; enclosures; brushes and slip rings; miscellaneous tools and machines; coil winding.

2-8 *Electronics*—Theory and parts; intercom systems.

2-9 *Testing and Maintenance*—Oscilloscopes; meggers; equipment and techniques.

MECHANICAL COMPONENTS AND DESIGN

(See 1-1 for mill supply catalogs)

3-1 *Bearings (A)*—Ball and roller bearings; housings and accessories; miscellaneous rolling contact bearings; cam followers; linear bearings; pillow blocks; spindles.

3-2 *Bearings (B)*—Other anti-friction bearings including oil lifts, hydrodynamic bearings, jewels, rubber and spring supports.

3-3 *Bearings (C)*—Sliding bearings; hinges; ball joints; rod ends; special designs for high temperature, dry operation, etc.

3-4 *Lubrication (A)*—Feeding of lubricants; housings and breathers.

3-5 *Lubrication (B)*—Lubricants; lubricant storage and reclamation; special surface treatments.

3-6 *Seals (A)*—Dynamic packings and seals, including stuffing boxes, V-packings, O-rings, labyrinth seals; scrapers; telescoping covers; bellows; diaphragms; boots.

3-7 *Seals (B)*—Static gaskets and seals, including cements and caulking compounds.

3-8 *Pipe and Connections*—Hose tubing, pipe and connection fittings including fabrication spray nozzles; rotary joints pipe insulation and heating.

3-9 *Pipe Fittings*—Other than connection fittings and spray nozzles; manual, check and solenoid valves; traps and float valves valve seats; filters and screens pressure vessels.

3-10 *Fasteners*—Rivets; pins keys; snap rings; wire locks machine screws and bolts; wood screws and timber connectors stud welding; blind fasteners other specials.

3-11 *Adjustments*—Quick-opening fasteners; latches; detents clamps; locks; cranks; knobs handles; pedals; indicating devices.

3-12 *Springs*—Materials and finishes; design and specification of various types; stock lists; inspection.

3-13 *Shock and Vibration Control*—Vibration theory, measurement, and isolation; balancing critical speeds and dynamic dashpots and shock absorbers noise control.

3-14 *Mechanization and Automation*—Hoppers, feeds, and transport mechanisms (see 6-1, 6- 6-8); machine control and sequencing (see also 2-5).

3-15 *Miscellaneous Components*—Head shapes; rings; balls; tubing; expanded metal; wire cloth "rigidized" metal; operator seats; rubber suction cups and bumpers.

FABRICATION METHODS AND DESIGN

4-1 *Nonmetals*—Molding, extrusion, drawing, and bending woodworking; gluing and heat sealing.

4-2 *Metals (A)*—General comparisons; miscellaneous methods including electroforming.

4-3 *Metals (B)*—Casting and extrusion; foundry layout and equipment; repair of castings

4-4 *Metals (C)*—Press working bending, stretching, spinning rolling, swaging, forging and stamping; powder metallurgy wire and strip handling.

4-5 *Metals (D)*—Welding, braz

headings may in turn be further subdivided if the volume of material warrants, although a classification loses effectiveness if subdivided more than necessary.

The Reference Data Classification System below, presents the present state of evolution of a successful classification system. This has been used for seven years in the development and design of special-purpose, high-production machinery and facilities as required for the fabrication, assembly, inspection and packaging of fasteners and other small mass-production items. It will be noted that classification of data is second-order only, into major divisions and subdivisions, although explanatory notes have been

SIFICATION SYSTEM

ing and soldering. (See 5-9 for hard facing.)

4-6 *Machine Shop (A)*—Machine tools; shop processes and practice; coolants, chip handling; machinability ratings, cutting times; flame cutting; design for machining.

4-7 *Machine Shop (B)*—Chucks, fixtures and accessories; tool bits and tool shapes; hand and sheet metal tools.

4-8 *Machine Shop (C)*—Non dimensional mechanical finishing, polishing and cleaning such as superfinishing, brushing, tumbling, shot peening, embossing, electrolytic polishing.

4-9 *Heat Treating*—Processes and equipment (see also 6-3); case hardening.

4-10 *Inspection*—Gaging and testing (see also 7-4); surface quality determination; automatic scanning, detection and inspection devices and machines; quality control; departmental organization.

4-11 *Assembly*—Fits and tolerances; assembly methods and equipment; design for assembly.

TERIALS AND FINISHES

(See 7-4 for Strength of Materials)

5-1 *General (A)*—Selection of materials and constructions for special requirements such as heat, cold, thermal expansion, high density, tropical service; radioactives; sandwich constructions.

5-2 *General (B)*—Corrosion, erosion and abrasion. (See also 4-9, 5-9, 5-10.)

5-3 *Metals (A)*—Ferrous.

5-4 *Metals (B)*—Copper-base.

5-5 *Metals (C)*—Nonferrous, other than copper-base.

5-6 *Nonmetals (A)*—Plastics and elastomers.

5-7 *Nonmetals (B)*—Other than plastics and elastomers.

5-8 *Fluids*—Properties and flow; water conditioning.

5-9 *Finishes (A)*—Plating, metal spraying and metallizing; hard facing.

5-10 *Finishes (B)*—Paints, enamels and flock; chemical cleaning methods and machines.

PLANT AND PROCESS

6-1 *Materials Handling (A)*—Continuous or bulk flow and storage; conveyors; chutes; magnetic separators; vibrating equipment; feeders; spouts; bins.

6-2 *Materials Handling (B)*—Individual transfer and storage; cranes, grabs and slings; vehicles; door openers; movable bridges; casters and wheels; skids, pallets and tote boxes; racks. (See 6-11 for protective coatings.)

6-3 *Heating and Drying*—General thermodynamics; furnaces; ovens; insulation; burners; fuels; electric heating; Dowtherm, steam and other heat-transfer materials; heat exchangers.

6-4 *Cooling*—Refrigeration and cooling; air conditioning.

6-5 *Pumps*—Centrifugal, rotary and reciprocating (see also 1-9); eductors.

6-6 *Fans*—Vacuum pumps, blowers and compressors; ductwork; dust collection.

6-7 *Process Controls (A)*—Instrumentation (fundamentals); dials and panels; recorders; transmitters; remote receiving devices; controlling devices and motors; maintenance.

6-8 *Process Controls (B)*—Weight and count (see also 6-11); speed (see also 1-5); acceleration; time recorders (see 2-5 for time and cycle controls).

6-9 *Process Controls (C)*—Pressure, flow and level.

6-10 *Process Controls (D)*—Temperature, humidity, pH, conductivity, viscosity and composition. (See also 4-10.)

6-11 *Packaging and Identification*—Packages and materials; package making and filling equipment; product marking and identification; shipping procedures; protective coatings.

6-12 *Chemical Processes*—Miscellaneous, including equipment.

6-13 *Plant Engineering (A)*—Design, construction and repair of buildings and roads; structures and materials; safety floor plate; lighting; heating; ventilating. (See also 6-3, 6-4, 6-6.)

6-14 *Plant Engineering (B)*—Maintenance procedures and control; plant and machine cleaning; tools and equipment for plumbers, tinsmiths and millwrights; jacks and ladders.

6-15 *Plant Engineering (C)*—Safety and fire protection.

6-16 *Prime Movers*—Steam and internal combustion engines and turbines; steam generation.

6-17 *Specific Industry*—Of special interest to user.

ENGINEERING

7-1 *Department Management*—Organization, planning and procedure; patents and legal matters; training and advancement; suggestion systems; accounting; engineering library.

7-2 *Department Equipment*—Office; drafting; reproduction.

7-3 *Costs*—Estimating; new machine justification; cost control; reduction in design and manufacturing costs.

7-4 *Strength of Materials*—Properties of materials (see also 5-1); testing machines and accessories including strain gages; stress analysis; residual stresses, fatigue and failure of metals; crack detection; photoelasticity and nondestructive testing. (See 3-13 for vibration theory and measurement.)

7-5 *Miscellaneous Test and Calculation*—Miscellaneous laboratory and scientific equipment and procedures (see also 2-9, 4-10); chart and nomogram construction; engineering mathematics; dimensional analysis; areas, volumes, moments of inertia; conversions, preferred numbers.

7-6 *Drafting and Design*—Drafting room practice, symbols, standards, dimensioning and methods of rendering; systematic design; styling; miscellaneous product descriptions.

7-7 *Management Engineering*—Methods and motion economy; time study; layout; production control; purchasing; wage payment; employee training; organization and administration.

7-8 *Professional Matters*—Organizations, licensing, standards and ethics; self-advancement; personal and community relationships and responsibilities.

7-9 *Services*—Special services and facilities.

found desirable to aid location of specific material and to prevent misfiling.

In order to facilitate filing and return of papers, there is applied to the subject-grouped framework a numerical coding system similar to the plan of the Dewey decimal classification found in major libraries. One deviation is suggested. To make the system clear at a glance a dashed number and letter coding, as 6-11 or 6-11k is used rather than the decimal 611.11. Roman numerals are not advised for coding under any circumstances: they are slow to write and prone to confusion, especially IV and VI. Occasionally mnemonic coding is used for the main headings, as "P" for Power, "S" for Shop, etc. Such coding has the disadvantage that a given letter means different things to different people: "P" might also suggest Plant, Protection, or Process Equipment and be more confusing than helpful. In general, whatever the coding used, it should be short and simple to avoid errors and unnecessary work.

Physical separation of data according to seven major divisions should be adequate for a library fitting in a single drawer. The 81 subdivisions can be added for a fairly large collection. If desired, sub-subdivisions can be established, possibly based on the explanatory notes provided for each subdivision. However, unless the volume of material clearly warrants it, a third-order division will be more trouble than it is worth. In general, when a particular folder gets too bulky one should merely add a second folder. When both are outgrown then it is time to sub-subdivide, sorting the material into various logical groupings and recombining as indicated by the natural affinity of topics and by the physical bulk of each.

With suitable modifications it is believed that the Classification System on page 112 should be useful to most firms or individuals employed in a design or development activity. For other possible classifications in the mechanical industries, the reader is directed to the data organization systems used in *Sweet's File, Marks' Handbook,* and *Kent's Mechanical Engineers' Handbook.* Specialized systems have been developed for certain specific industries, including metal finishing,[5] welding,[6] and metallurgy.[7]

Housing the Data File

The data collection must be adequately housed. The author's collection is kept in 92 sturdy, pocket-type file folders (one for each of the 81 subdivisions plus 11 extras to take care of certain over-expanded subdivisions). The folders are housed in seven portable shelving units each three feet long by one foot square. To minimize floor-space requirements and make the heavy file folders easier to withdraw and replace, the folders are set on their side, bookcase fashion. Ordinary letter file drawers can be used, although bookcase-type filing is believed superior.

Each file folder is labeled with title and code number, color coding being used to help distinguish between the major divisions. The reader is advised to purchase folders made of pressboard or other heavy board, preferably fitted with metal tabs for permanence. The optimum folder thickness is found to be between one and three inches. Too thin a folder means either not enough filing capacity or folders crammed full of material, while too thick a folder means awkward handling and wasted time. When a folder grows beyond three inches, additional folders should be provided or, if necessary, material should be reclassified.

Where the collection is to be handled as a company project, it is recommended that a designer or engineer be appointed librarian. All catalogs and mailing pieces coming into the department should be routed across the librarian's desk for evaluation and coding if worth keeping. The letter of transmittal, if any, should be stapled inside, because this usually gives the name of the local distributor.

Filing Large Catalogs

There are several practical ways of handling large or complicated catalogs covering many different subjects, such as mill supply, hardware or electrical supply house catalogs. One is to dismember them, particularly if duplicate catalogs are available to take care of different topics back-to-back on the same page.

If dismembering is impractical, general catalogs can be filed under *1-1* or *1-2,* both general classifications, and cross-reference sheets be placed under other classifications. If desired, the larger, heavier catalogs can be housed in a bookcase or cabinet, only the cross-reference sheets being kept in the file.

In addition to catalogs, the other members of the group should refer to the librarian any magazine articles, data sheets, clippings or advertisements that seem pertinent to the range of work being handled. Technical magazines are usually annotated, then finally dismembered. The pages of the desired articles are stapled together with title facing out and filed with the catalog for speedy reference and minimum bulk. Cross-reference notes or preferably photostats or reprints can be used when two articles scheduled for filing are back-to-back.

The remaining details are handled by the departmental stenographer. It is her job to cement clippings to a full-size protective backing sheet, to type needed cross-references, to stamp each item with the date and department name, and to file and return to file all material. As an additional insurance against loss or delayed return of material it may be desirable for her to keep a charge-out sheet.

Files should be reviewed periodically by the librarian. Errors are corrected; duplicate or obsolete material is discarded; information requests are sent for replacement of over-age catalogs. Incidentally, the catalog request cards offered by trade journals and papers offer an excellent and economical means for expanding the file and keeping it abreast of latest developments.

The subject classification system described is quick and easy to maintain and use; however, it is limited when extensive cross-referencing is desired. There also may be objection to dismembering trade journals, on the reasonable basis that some valuable material will be inadvertently discarded. On the other hand, when trade journals are bound with annual indexes, the designer is required to search in too many places.

These objections can be met, at some cost, by the

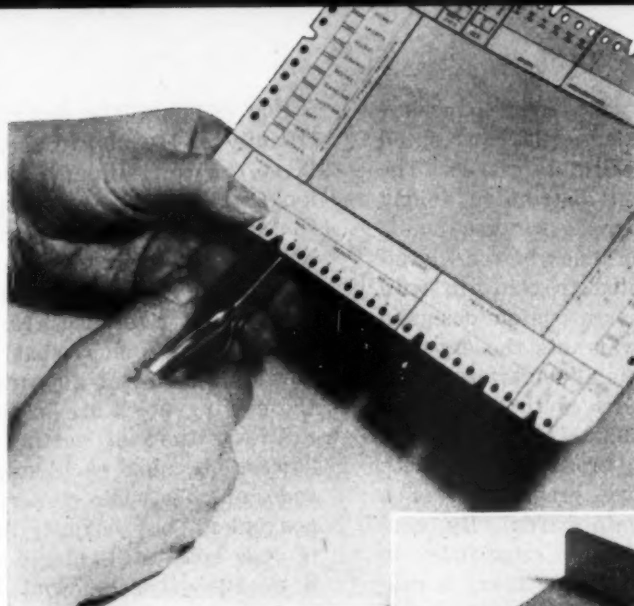


Fig. 2—Right—To index a reference, the margin of the appropriate code number hole is slotted out with a hand punch

Photos, courtesy McBee Co.

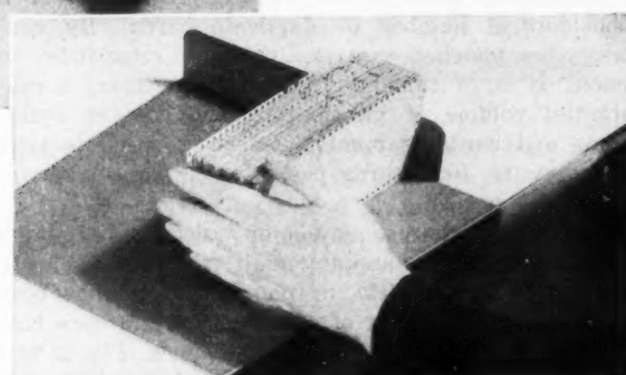


Fig. 3—Below—In locating data, punched cards are first squared to line up code number holes

use of a file-card index to supplement the subject file. Similar to that found in public libraries, this system uses reference cards located under both subjects and manufacturer's name.

Each card should supply code number, card filing title, actual title, date, and author or company name. In addition, it should offer a short summary of the article or catalog contents, sufficient to tell the reader whether it is likely to help him on his particular problem. To permit cards to be brought up to date when the catalog or material becomes obsolete, the card filed under company or author's name should serve as a master, listing all cross-reference cards for the given reference source.

A number of devices have been developed for speeding up use of the card index. These include a rotating-wheel card file and several types of "visible record" systems.

Like everything else, the file card system has its disadvantages. Principally there is the matter of time and cost: abstracts must be prepared; a file card must be typed for each and every cross-reference; cards must be filed in order and kept in order. The amount of work involved is apt to be far beyond the resources of an individual attempting to build a personal data file and difficult for a small company. Furthermore, the selection of effective file-card titles will be found a very real problem, as will be the maintenance of consistency in titling over the years, particularly with personnel shifts.

A last objection is that the card-index systems are relatively inflexible: once the system framework is established, it cannot be altered without a great deal of labor. Accordingly it is suggested that on starting a new data collection, the introduction of file cards be deferred until the pattern of the material collected is clear.

A highly interesting approach to the limitations discussed is found in the punched-card index system. Punched cards eliminate some of the work associated with the ordinary file card, and at the same time permit a complete cross-index on a single card. The system has been adopted with enthusiasm by metallurgists,[7] welders[6] and chemists,[8] to mention a few, because it provides them with a remarkably effective means for indexing and cross-indexing data on mixtures and properties. However, as far as has been determined punched cards have not yet been applied in the machine-design field.

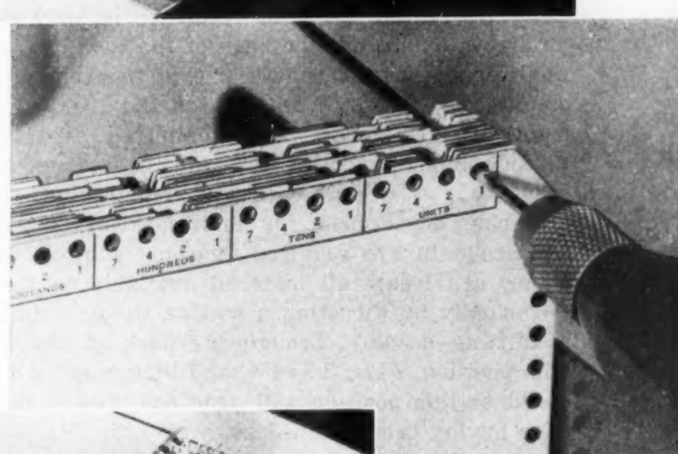


Fig. 4—Above—A sorting needle is thrust through the coding hole at the correct location

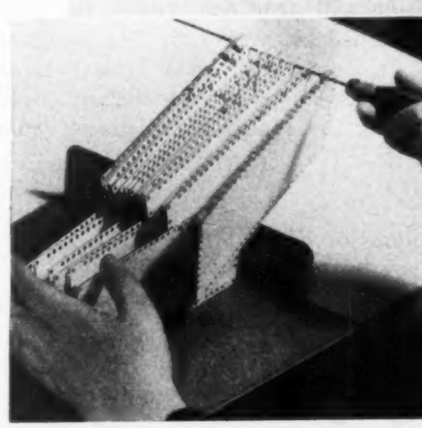


Fig. 5—Unwanted cards are lifted away. The desired reference will be found among the remaining cards

A typical stock punched card marked to fit the Reference Data Classification Chart is shown in *Fig.* 1. This card has 99 keying holes, and the chart has 81 subdivisions. Accordingly part of the 18-

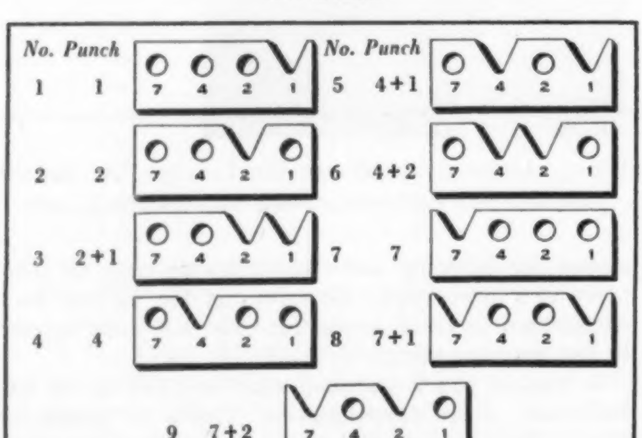
hole excess has been used for a cross-index, classifying the reference as a data sheet, article, etc., to speed sorting when looking for a specific reference. The remaining seven holes have been distributed among the seven major divisions to provide for growth. If desired, reference numbers in the index of the Classification System could be adjusted to conform with the printing on the stock card, or a custom-designed card can be printed if volume warrants the expense.

The reference selected for this illustration is the editorial section on high-speed drives that appeared in MACHINE DESIGN for April, 1950. In view of the broad coverage of this section, cross-indexing with ordinary file cards could involve preparation of a considerable number of duplicate cards. By contrast, the punched card is a complete cross-index in itself. It is, or can be, large enough to carry a substantial volume of information, and cost of equipment and cards is nominal. Sorting speed is very high, up to 1000 cards per minute, yet no special training is needed.

Some details on use may be of assistance. After the card has been typed and any additional data in mimeograph, microfilm, ditto, or photostat form has been pasted on, the margin of each appropriate code hole is slotted out with a special hand punch, *Fig.* 2, and the filing location for the reference is marked with an arrow. Note that the back of the card can also be used for information, and that clippings can be pasted on directly, without bothering to file them with the main data collection. The completed card can be placed immediately in the file pack (no special sequence), or it can be first routed through the engineering department for informational purposes.

When data are required on some subject, the designer can locate all material available on the subject simply by thrusting a sorting needle (similar to a knitting needle) through the pack at the desired hole position, *Figs.* 3 and 4, and lifting up. All cards coded to this position will drop out, due to the hole edge having been notched away, *Fig.* 5. The designer reviews the cards, selects those that appear most promising, and gives them to the stenographer to guide her in removing the required references from the literature files.

Fig. 6—"Field" coding of digits 1 through 9. Zero is not coded



For example, the designer may be interested specifically in the article used for illustration in *Fig.* 1. If so, he can minimize the number of cards to be looked through by using the needle once again. After the first sorting, he thrusts the needle through the hole in the upper left-hand corner marked "article," and among the several cards that drop out, he finds the desired reference. Note that before sorting the pack, the designer must first make sure that the beveled corners of all cards are at top right so that the sorting holes are in the proper location.

The method of sorting just described is termed "direct" because each hole corresponds to a specific code number. Direct sorting is fast, accurate and convenient, but is quite limited in the total number of code holes available. A larger card (maximum size 8 by 10½ inches) would offer more holes, but the cost and bulk of the cards would mount. The practical limit for the illustrated direct-sorted card would be something like 10,000 total reference cards.

"Field" Coding Overcomes Limitations

The method developed for overcoming this limitation is termed "field" or "numerical" coding. Fields are shown around the outside of the card as groups of the four numbers, 1, 2, 4 and 7. By punching any one or two of these it is possible to make each field represent a digit in a code number (*Fig.* 6). Zero is not punched. For example, the top row of the card shown in *Fig.* 1 contains seven fields, so that it can represent any single number from 1 to 6,999,999. Alternately, the top row might be broken down into three groupings, one capable of numbers up to 699 and the other two of numbers up to 99.

If the card shown in *Fig.* 1 were field coded on all four sides, it would provide a three-field grouping capable of keying any number from 1 to 999 for each of the seven major divisions in the Classification Table. Accordingly, it would be possible to establish a large bank of sub-subdivisions under each present subdivision. Such a breakdown should be adequate for even a very large reference library.

Field coding has two fundamental limitations: it is slow, and it interferes with cross-indexing since only one number can be shown in the field grouping for each major subject division. When cross-indexing is required within a major division, then a duplicate card must be prepared. In view of these drawbacks, it is customary to use field coding only where direct coding will not do, such as representing one large number like a date, patent number or drawing number. Letters can also be field-coded, using five keying holes per field.

Filing and data classification can be mechanized to a considerable degree. One method uses the standard tabulating punched cards and equipment made by IBM and Remington Rand. This has been applied very effectively in the fingerprint files on the FBI.

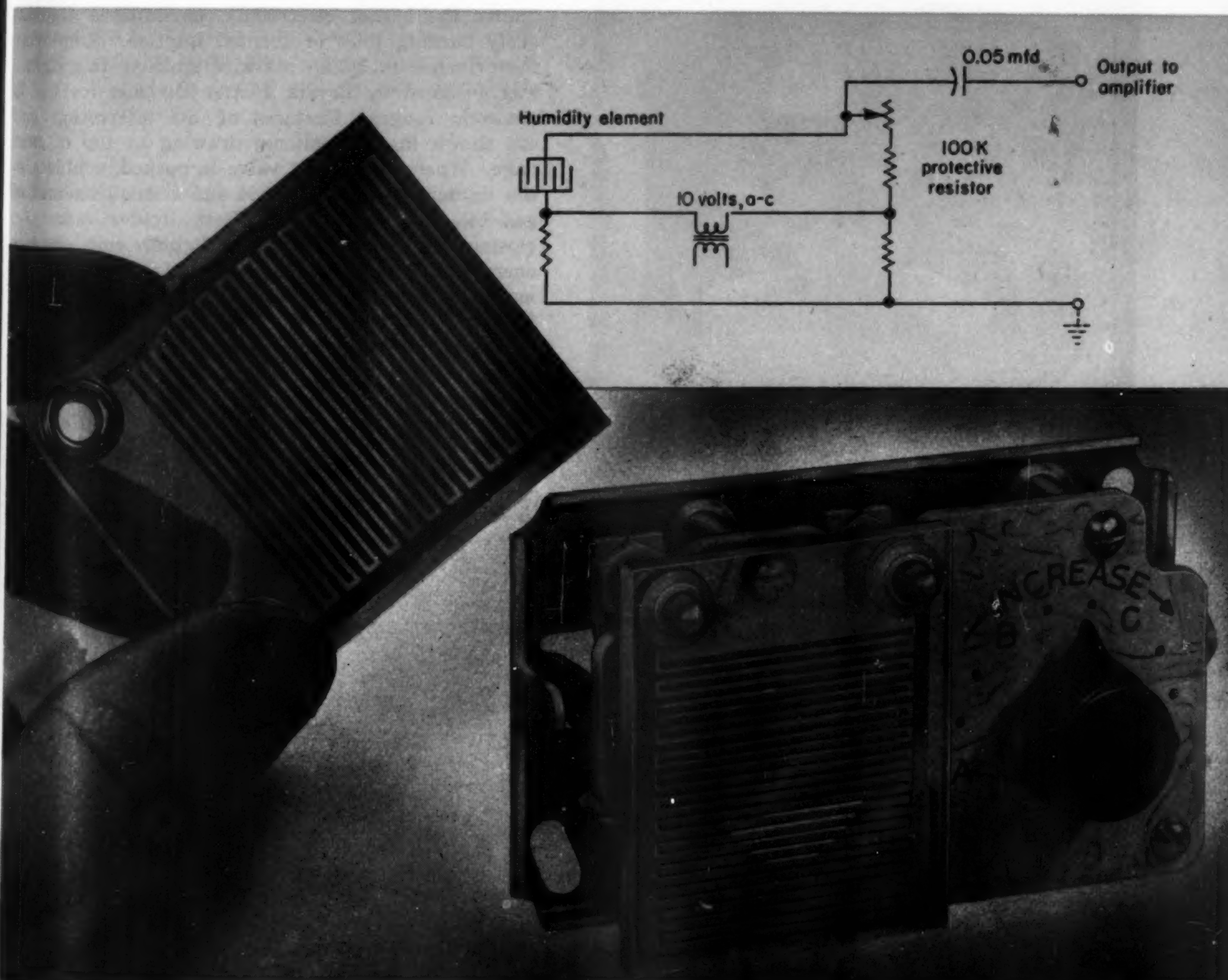
One of the latest developments in mechanized filing consists fundamentally of a microfilm record which is coded for photo-electric scanning. The operator inserts a master code "request" card in the selection machine and pushes a button. Half a million refer-

(*Continued on Page* 196)

SCANNING the Field For Ideas

Humidity sensing element, in the form of a grid in the control unit below, indicates relative humidity by a variation in the electrical resistance of a hygroscopic film. It responds rapidly to humidity changes, the logarithms of the electrical resistance of the element being a linear function of the relative humidity, and provides a convenient means for measuring, controlling or recording when connected in a Wheatstone bridge circuit such as illustrated in the diagram.

As shown in the photograph the electronic humidity element has two gold electrodes embossed on a moisture-resistant plastic base. On the grid, a thin coating of hygroscopic salts in a plastic carrier has the ability to absorb moisture in varying amounts, depending upon the humidity. As the moisture content

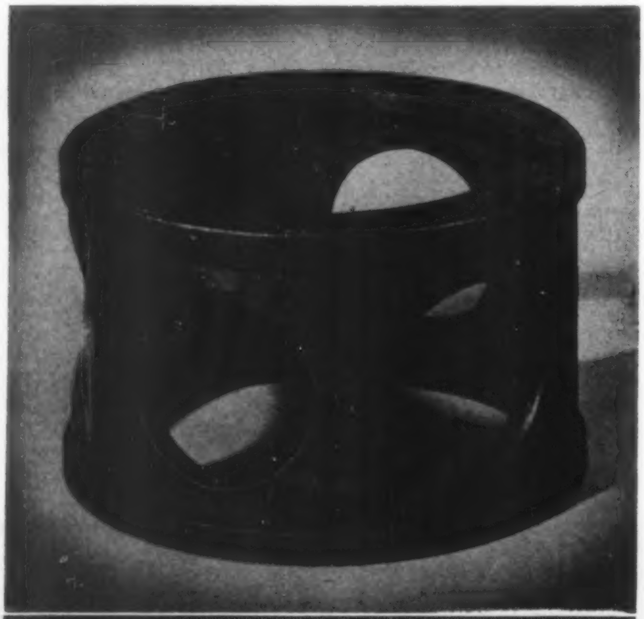


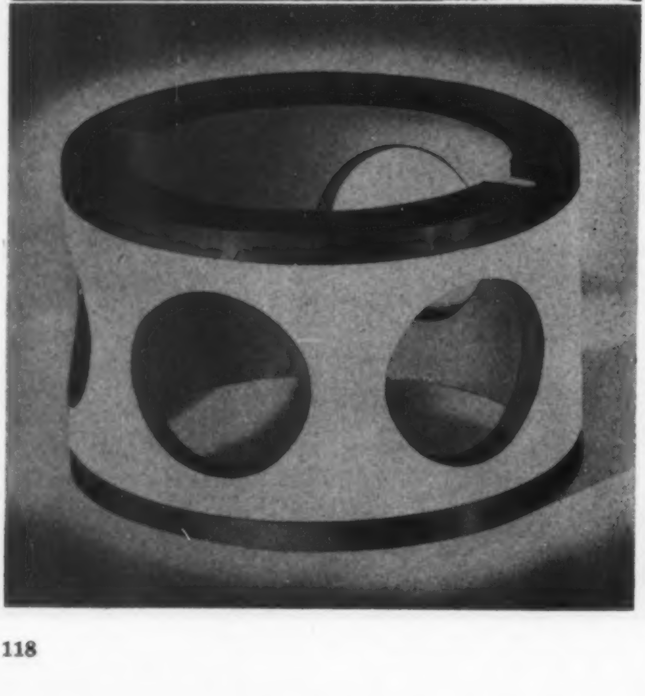
of the film becomes larger it becomes more conductive. Developed by the Minneapolis-Honeywell Regulator Co., the element can detect relative humidity changes within 0.01 per cent, but when used with a two-position amplifier the differential usually is adjusted between 0.5 and 5 per cent.

Porcelain enamel, ground and lapped, provides a wear-resistant, nongalling and noncorrosive surface on the valve plug illustrated below. Designed for an aircraft fuel selector valve, this part must function under extremes of temperature, humidity, atmospheric contamination, and corrosive conditions. In addition, it must be capable of operating totally dry over several thousand cycles without galling or excessive wear. Most of the possible metal choices failed in the dry-operation test.

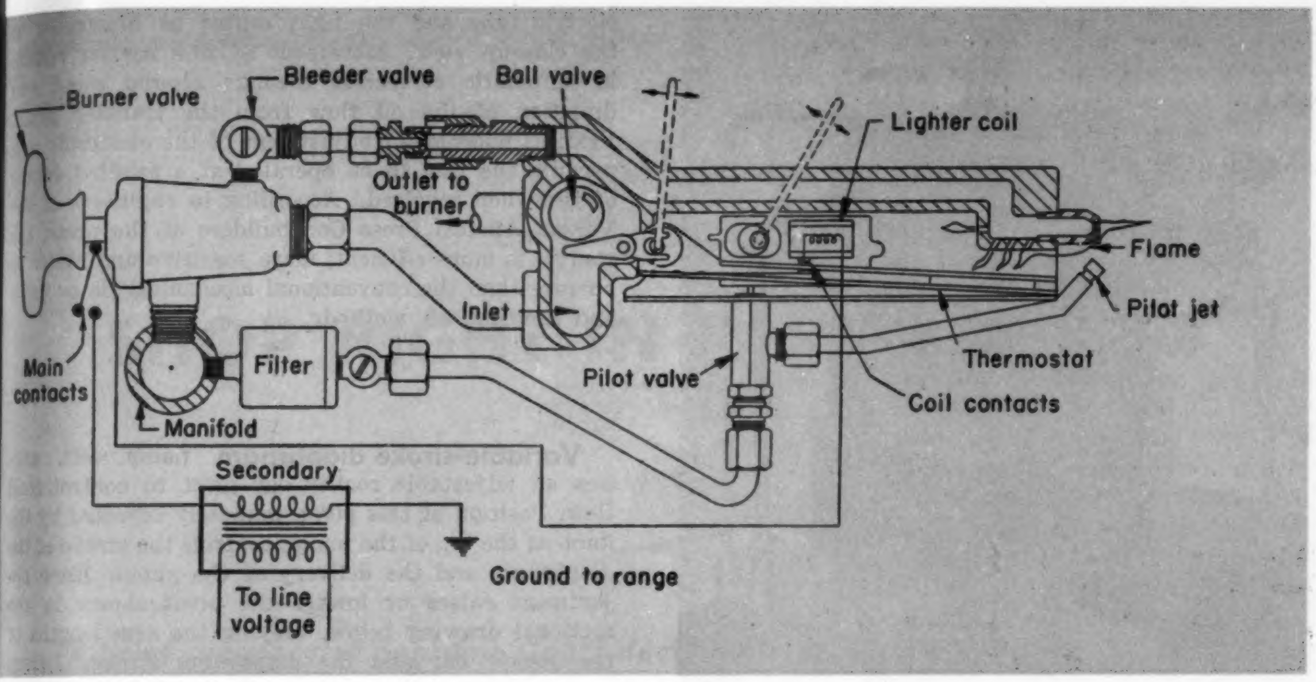
The plug for this valve, perfected by the Aero Supply Manufacturing Co., is cast in stainless steel and recessed to receive 0.015 to 0.020-inch enamel. The outer diameter, which is the wearing surface in contact with the valve seals, is porcelain enameled before final finishing takes place. Top and bottom rims are not enameled. In addition to the dimensional tolerances of the enameling operation, control of the enamel formula and firing temperature assures a fully matured enamel at a furnace firing temperature which will not cause warpage in the casting.

An unusual operation, generally not considered in connection with the use of porcelain enamel, is the final grinding and lapping on the external diameter which brings finished tolerances of the plug to within plus 0.001 and minus 0.000-inch. The enamel is an acid resistant type developed by The Erie Enameling Co. for this job. Evidence of the practicability of this surfacing is found in service records which show that all-metal valves require maintenance in about three months whereas a prototype of this valve has been in operation for over five years.





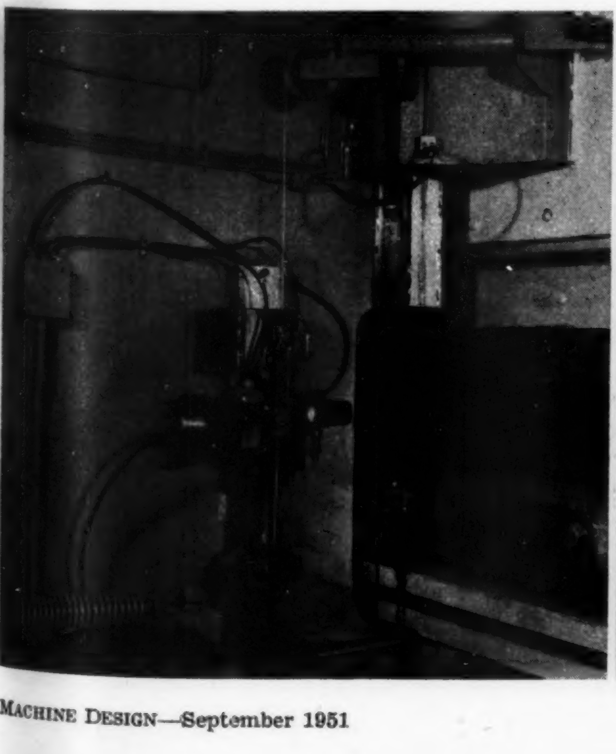
Automatic lighter, below, for gas oven burners ignites the burner electrically, obviating a continuously burning pilot or manual ignition. Employing the principle of cyling hot-wire ignition, this lighter was designed by Bryant Heater Division for use in domestic ranges. Features of the interesting unit are shown in the sectional drawing at top of next page. When the burner valve is opened, contacts to the lighter circuit are closed and a small amount of gas bleeds through an auxiliary lighter valve. On closing of the contacts, the lighter coil becomes energized through the secondary of a constant-voltage transformer. Heat from this coil ignites the bled gas and the flame, playing on a thermostat, causes it to deflect. This opens the lighter coil circuit

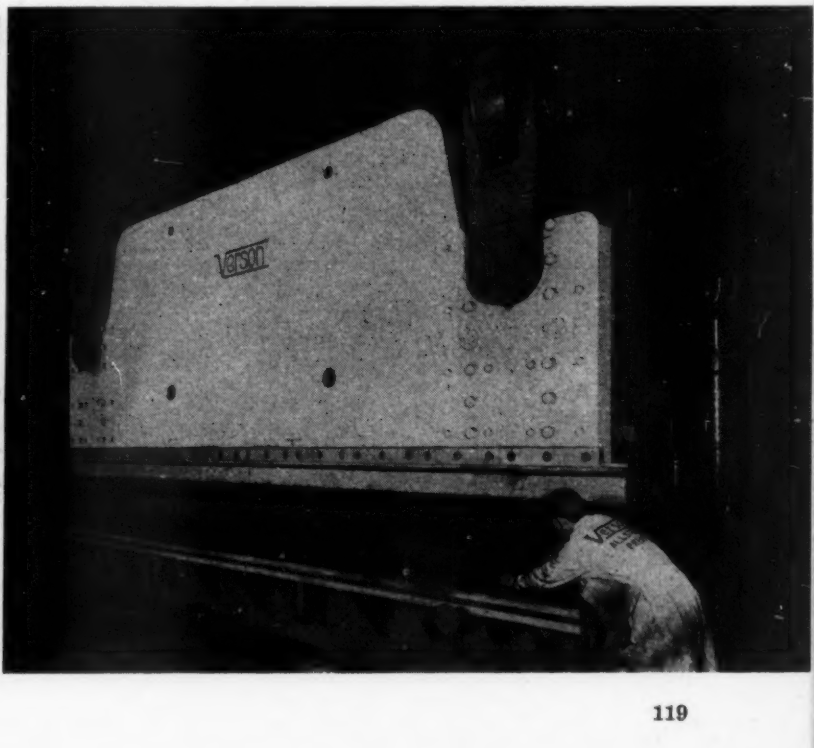


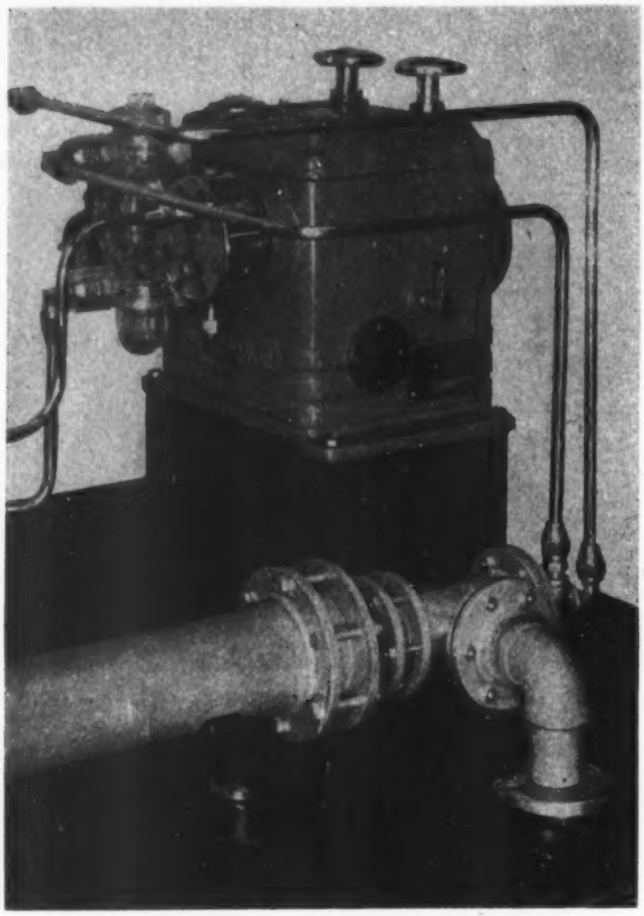
as well as the pilot jet valve, lighting its jet. Further deflection of the thermostat opens a ball valve to admit gas to the main burner, completing the cycle. The pilot remains burning as long as the burner valve is open. Should the burner and its pilot become extinguished for any reason, the thermostat will cool and close both the ball and pilot valves, cutting off all gas supply except to the bleeder valve. At the same time the heater coil contacts close and the unit recycles to light the burner.

Photoelectric control of the ram motion on the hydraulic press brake below, provides a convenient and precise setting for the press stroke. Actuated by two independent hydraulic cylinders supplied from separate matched pumps, the press may be operated to have the ram travel level through its stroke or to tilt at a preselected angle, accurate to a thousandth-inch. A reversible booster pump transfers oil from one line to the other to maintain position synchronization of the ends of the ram.

Driven by a motor supplied by an amplidyne generator, the booster pump is actuated by the General Electric electronic system. Any tilt of the ram raises or lowers a barrier suspended between the photo-

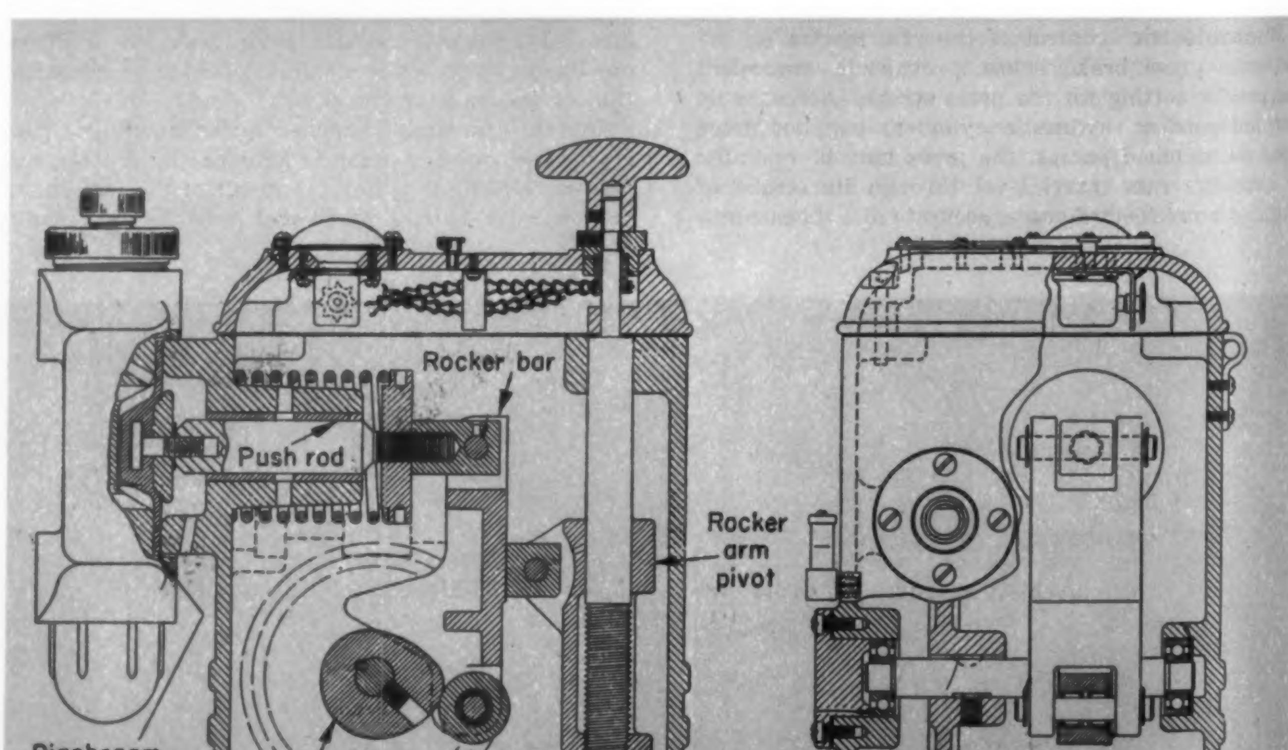


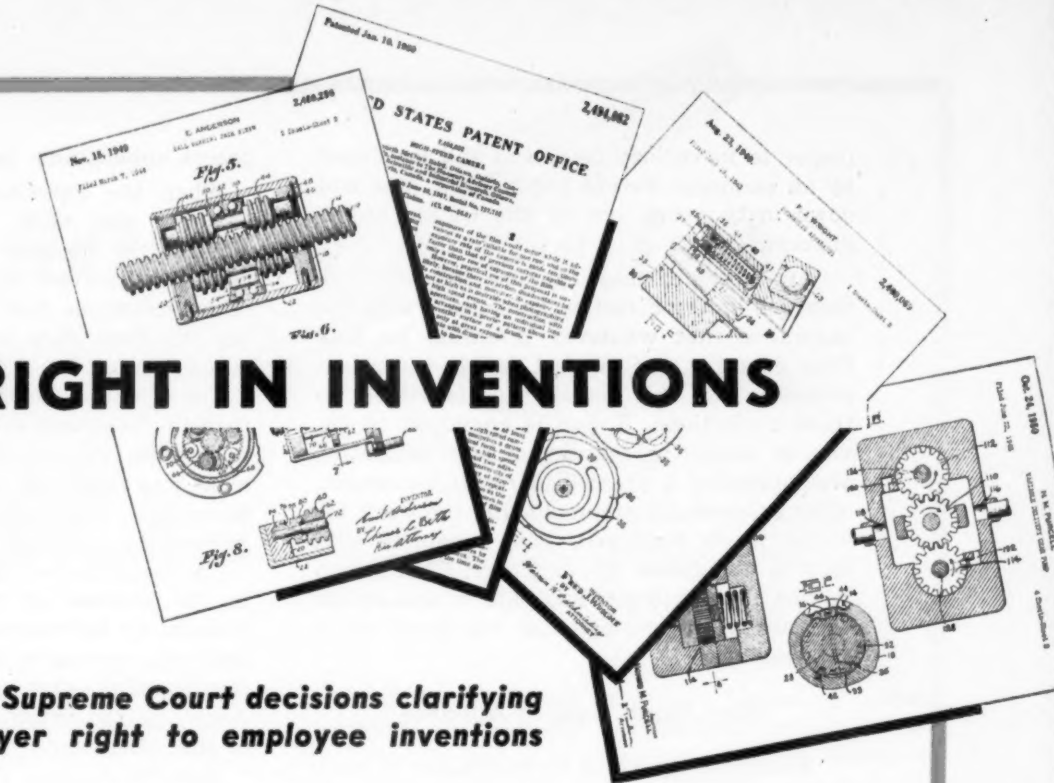




electric tube and the light source as illustrated in the closeup view. Movement of this barrier results in automatic correction through altered speed and direction of the oil flow from the transfer pump. Vertical micrometer adjustment of the electronic unit permits the ram to be operated at a selected degree of tilt when required. According to engineers of the Verson Allsteel Press Co., builders of the press, the control is more efficient, more sensitive and easier to operate than the conventional mechanical tie or valve and limit-switch methods.

Variable-stroke diaphragm pump, left, utilizes an adjustable rocker bar pivot to control fluid flow. Position of this pivot, manually adjusted by the knob at the top of the pump, controls the stroke of the diaphragm and the delivery of the pump. Knob adjustment raises or lowers the pivot shown in the sectional drawing below, varying the arm lengths of the rocker bar and the diaphragm stroke. Driven at one of three speeds by a 3-step V-belt pulley, a cam operates the rocker arm about its pivot pin. This actuates the diaphragm through its push rod, delivering fluid through the pump chamber. This chamber, being completely sealed, prevents any contaminants from entering. Designed by Proportioneers Inc., the pump is a dual unit, each unit being adjustable independently to minimize flow pulsations.





SHOP RIGHT IN INVENTIONS

A brief summary of Supreme Court decisions clarifying the area of employer right to employee inventions

By Albert Woodruff Gray

Jackson Heights, L. I. New York

AN EMPLOYEE of a well-known manufacturer at the beginning of his employment signed an agreement with his employer that he would disclose to the company "all inventions made, developed, perfected, devised or conceived" by him during this employment. Further, that should the employer fail to elect to prosecute a patent application on any of such inventions following such complete disclosure, then all the rights of the company should lapse, except that the company should have a free shop right in such inventions.

Several years later when the inventor was no longer in the employ of the company and the company had failed to avail itself of an invention submitted under the terms of this agreement, this employer, without the consent of the inventor, appropriated to its own use an invention that had been patented by this employee.

Two and a half years after he made this agreement with the company the employee had submitted the details of this invention and shortly afterwards his specifications and memorandum had been returned to him by the company with a pencil notation, "Not interested at this time."

Later, after the inventor's employment with the company had ended, the manufacturer discovered the merits of the invention it had rejected. In a decision a few months ago in favor of the owner of this patent, in his action against the airplane manufacturer for infringement, the Federal Court said of that pencilled note, "Like the 'damned spot' in Macbeth, it will not out, for it spells rejection of the invention."

"The pattern this lawsuit discloses is this," continued that court, "this employee was rebuffed at all times in his efforts to interest his employer in an invention he had conceived and perfected before his employment. The employer rejected the idea as impracticable and then after its judgment had proved faulty and the invention had been patented this employer sought to assert rights thereto."

An essential phase of this situation that served to influence the decision under which the employer was excluded from even a shop right in this invention was not only that the employer had failed to avail itself of its rights under the original employment contract but that, according to the court, "The invention was conceived before the inventor entered this employment; that it was complete at that time and that nothing was added to the conception by the inventor during his employment."

The rule governing the right of an em-

ployer to inventions conceived and developed by an employee during employment, was laid down sixty years ago by the United States Supreme Court.

"An employee may exercise his inventive faculties in any direction he chooses with the assurance that whatever invention he may thus conceive and perfect is his individual property. But this general rule is subject to these limitations. If one is employed to devise or perfect an instrument or a means for accomplishing a prescribed result he cannot, after successfully accomplishing the work for which he is employed, have complete title thereto as against his employer. That which he has been employed and paid to accomplish becomes when accomplished, the property of the employer.

Shop Rights Sold in Advance

"Whatever rights as an individual he may have had in and to his inventive powers and that which they are able to accomplish he has sold in advance to his employer. So also when he is in the employ of another in a certain line of work and devises an improved method or instrument for doing that work, and uses the property of his employer and the services of other employees to develop and put into practical form his invention and explicitly consents to the use by his employer of such invention, the court is warranted in finding that he has so far recognized the obligations of service flowing from his employment and the benefits resulting from his use of the property and the assistance of the co-employees of his employer, as to give such employer an irrevocable license to use such invention."

This license or shop right for the use of an invention however, must not be confused with the proprietary ownership of patents. Two scientists made a contract with a chemical company under which the company furnished a laboratory and such equipment and chemicals as were necessary. The scientists gave the company an option for the purchase of all inventions of processes for special types of chemical production with the further agreement that should the company exercise this option the scientists would comply immediately and assign to the company an exclusive license to all patents which had been or would be granted to the scientists on these inventions.

The men proceeded with the development of the specific inventions. However, during the succeeding eleven months they also developed other inventions in the laboratories of the company and subsequently they filed patent applications for these inventions.

When the agreement ended between the company and these men, the company demanded the ownership of not only the inventions described in the agreement but all other inventions that had been conceived during the time they had been in the employ of the company.

The scientists on the other hand contended that the company was entitled only to those inventions that existed at the time the agreement was made and not to the inventions and ideas that, when the agreement was made, had not been reduced to practice.

"A conception of the mind," said the court in its decision of the action subsequently brought by the company, "is not an invention until represented in some physical form and unsuccessful experiments or projects abandoned by the inventor are equally destitute of that character."

This the Federal Court supplemented with a statement of the law that relates to inventions, made by an inventor while employed by another in research, which are entirely outside the scope and meaning of such employment.

"The fact that certain inventions were made by a chemist while he was upon the employer's premises and with the employer's laboratory, facilities, materials, funds and property, does not give the employer any proprietary interest in the inventions in the absence of an express agreement to that effect; but it does give the employer a shop right to use processes developed on its premises and at least partially at its expense."

If, however, the inventions which the employee develops are directly within the terms of the employment contract then the employee has no proprietary right in them and they are the property of the employer.

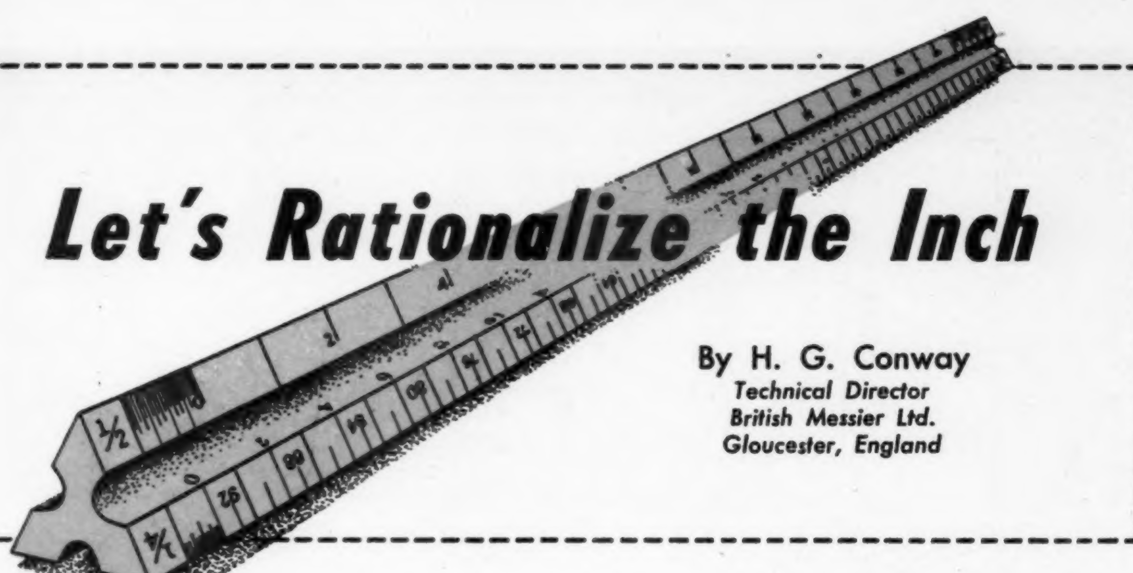
Agreements Must Be Specific

A large soap producer ten years ago employed an expert in that field under an agreement that the employee "would employ his knowledge, experience and efforts in the improvement of the products, equipment and processes of the employer."

During the next six years this employee filed three patent applications. At the termination of the employment the ownership of these patents was claimed by both employer and employee.

The decision of the Federal Court of Appeals in the action brought by the inventor against the employer for damages for the appropriation and use of these patents sets out

(*concluded on Page* 198)



Let's Rationalize the Inch

By H. G. Conway
Technical Director
British Messier Ltd.
Gloucester, England

AMERICAN engineers are unusually receptive to constructive criticism; maybe they will not object to a European commenting that they often appear to others to be an extraordinary mixture of the logical and illogical. American production methods are unequaled throughout the world and the activities of American designers and production men have the respect of engineers from all other countries. Yet at times their retention of out of date practices seems, to say the least, astonishing.

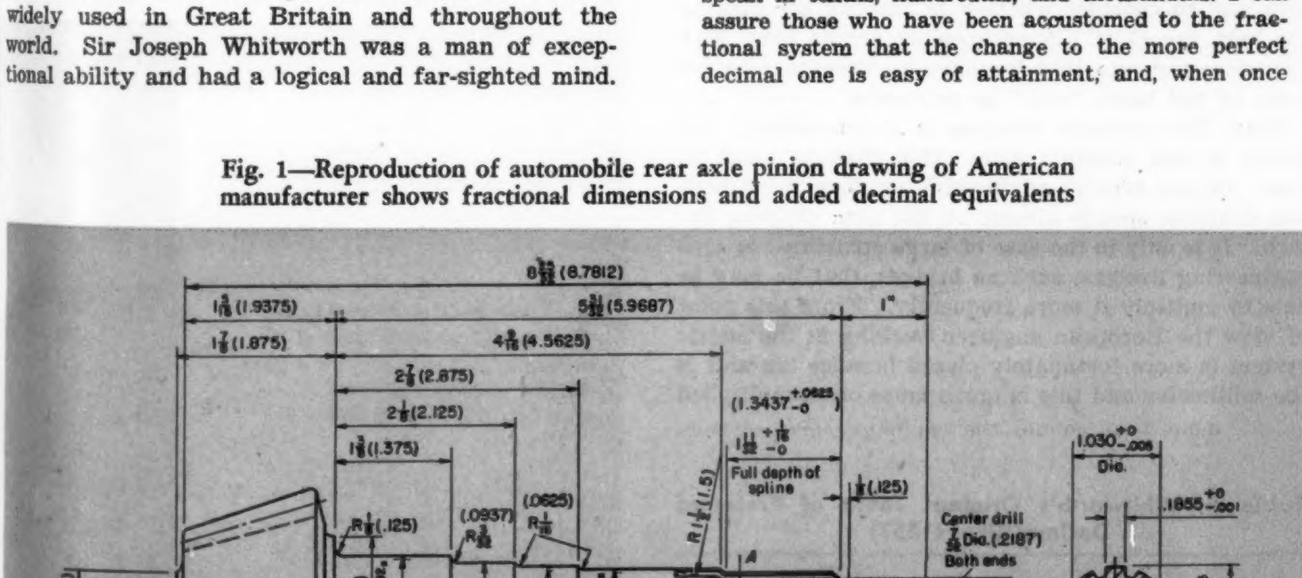
An example of this is the continued use of the fractional inch system in the United States.

It is almost one hundred years, 1857, to be exact, since Sir Joseph Whitworth originally made his proposals for the Whitworth thread system at Manchester, England. This system was the forerunner of all standard thread systems and in fact is still widely used in Great Britain and throughout the world. Sir Joseph Whitworth was a man of exceptional ability and had a logical and far-sighted mind. He may be considered to be the father of modern metrology and certainly was the first person to evolve an accurate gaging system and accurate means of measuring parts with his "millionth measuring machine." It is not often appreciated, however, that his original proposals for a standardized gaging and thread system consisted of a series of decimal diameters which might or might not be threaded. A copy of his original table is reproduced in TABLE 1.

In presenting his standard Whitworth said:

"I have long been convinced that great and rapid progress would be made in many branches of the mechanical arts, if the decimal system of measure could be generally introduced. To state the case broadly, instead of our engineers and machinists thinking in eighths, sixteenths, and thirty-seconds of an inch, it is desirable that they should think and speak in tenths, hundredths, and thousandths. I can assure those who have been accustomed to the fractional system that the change to the more perfect decimal one is easy of attainment, and, when once

Fig. 1—Reproduction of automobile rear axle pinion drawing of American manufacturer shows fractional dimensions and added decimal equivalents



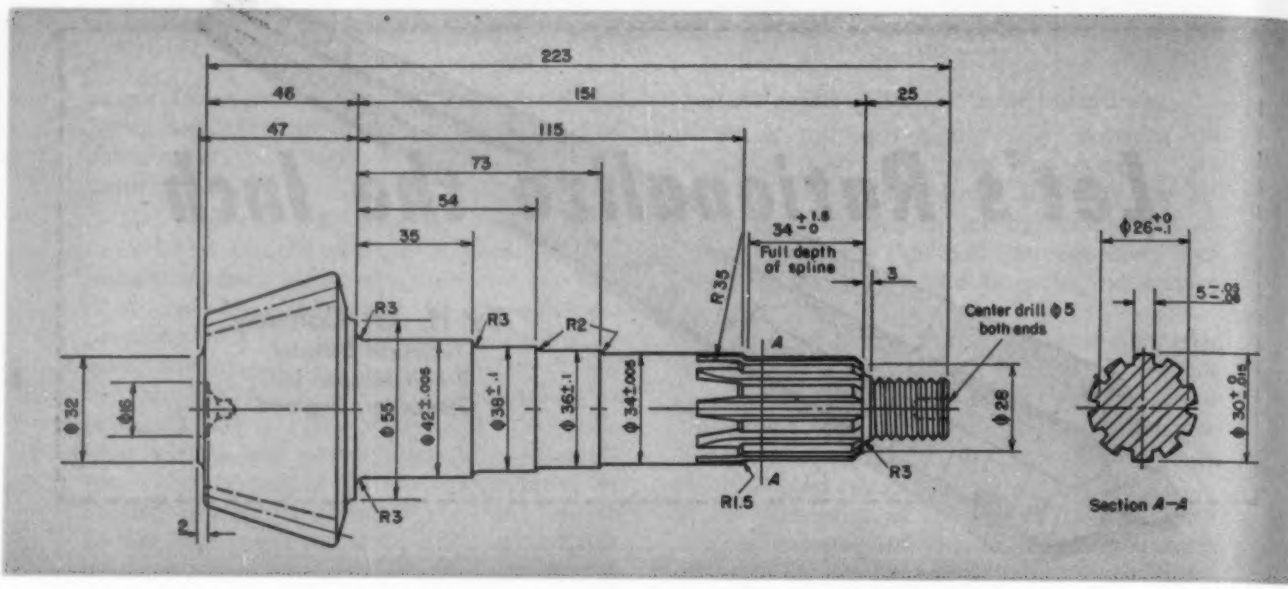


Fig. 2—Metric system equivalent of drawing shown in *Fig.* 1 has only 46 per cent as many numbers or decimal places

made, it will from its usefulness and convenience amply repay any trouble which may have attended its acquirement."

These remarks can only be echoed today. What most engineers do now, of course, is to think in eighths and sixteenths but to express themselves in decimals. This leads to the production of drawings with dimensions expressed in three or sometimes more decimal places. Drawings are thus a mixture of sixteenths, with four decimal places, thirty-seconds, with five decimal places and sixty-fourths, with six decimal places.

However commonplace it may be, it is worth while now to have a look at the unit which the engineer uses and to consider whether in fact we are making the best use of it. Sometimes we are so busy with new developments that we have no time to consider some of our basic "tools" or processes.

What the engineer requires is a dimensional unit which he can multiply more often than he must divide. On the average engineering product, the American engineer spends almost all his time dividing the inch. It is only in the case of large structural or civil engineering designs, such as bridges, that he may be able to multiply it more frequently. From this point of view the European engineer working in the metric system is more fortunately placed because his unit is the millimeter and this is much more often multiplied than it is divided. However, even the European engineer, when he comes to manufacture such small items as clocks and watches, makes use of a unit of one hundredth of a millimeter and makes all his designs in multiples of this.

It was because the inch was too large that the old-time engineer made use of the sixteenth and the thirty-second; they were, in fact, dimensionally convenient engineering units but for the fact that they had to be expressed as fractions. As engineering became more precise, the old-fashioned habit of thinking in terms of "a bare sixteenth" or "a full thirty-second" had to be abandoned and the natural unit

Table 1—Whitworth's Original Table of Preferred Decimal Sizes (1857)

			.525		2.125	
		.275	.550	1.125	2.250	
			.575			
	.150	.300	.600		2.375	
			.625	1.250	2.500	5.000
		.325	.650		2.625	5.250
			.675	1.375	2.750	5.500
	.175	.350	.700		2.875	5.750
		.375	.750	1.500	3.000	6.000
.100	.200	.400	.800	1.625	3.250	
		.425	.875	1.750	3.500	
	.225	.450	.900	1.875	3.750	
		.475				
.125	.250	.500	1.000	2.000	4.000	

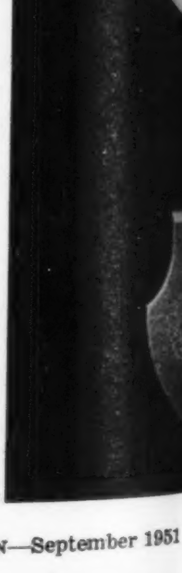


Fig. 3 — Metric micrometer, top, is easier to read than conventional inch micrometer and does not require the usual fraction—decimal conversion scale

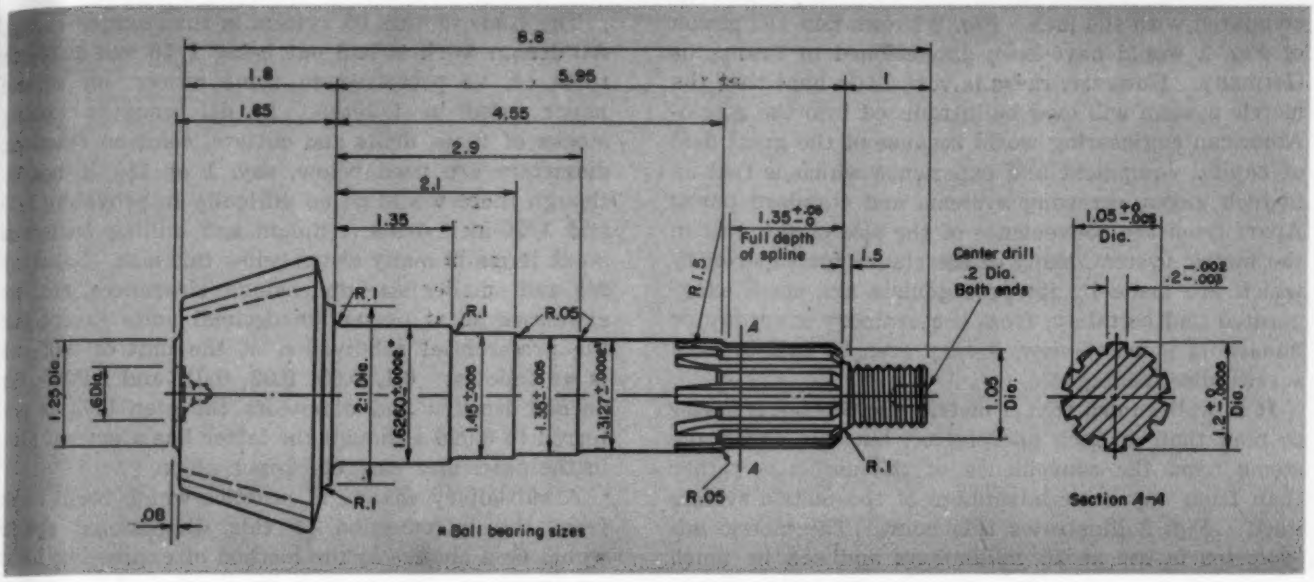


Fig. 4—Same drawing as in *Figs.* 1 and 2, dimensioned in the 1/20-inch system, requires only 56 per cent of the numbers on the original "inch" drawing

was the thousandth of an inch. So ingrained, however, had become the thirty-second mentality that engineers continued and still continue to design in this unit but to express dimensions in thousandths of an inch. *Fig.* 1 is a reproduction of a rear axle pinion drawing as used by a well-known American automobile manufacturer. The fractional dimensions have been faithfully reproduced from the original, but the decimal dimensions in brackets have been added, as they must inevitably be, by the production engineer.

One obvious solution to the unit problem would have been to rename a thirty-second of an inch arbitrarily and to work in multiples and decimals of that; however, since a thirty-second is not a convenient decimal unit, its decimalization would present various practical problems.

From the point of view of the design engineer, the metric system, or to be more correct, the millimeter system offers great attraction. The average engineer is not so concerned about the advantages of the centimeter-gram-second system as the scientist, but any engineer who has had experience with designing in millimeters will know what a convenient unit it is

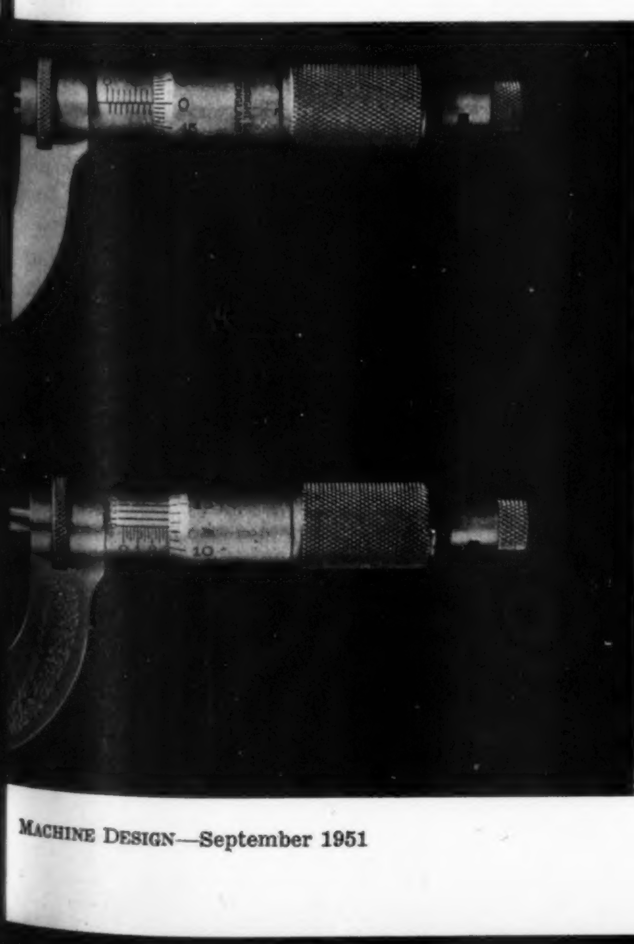


Table 2—American and British Large Diameter Threads Compared (inches)

AMERICAN (H.28)	BRITISH (First Preference)	BRITISH (Second Preference)
1.5	1.5	
1.5625		
1.625		1.6
1.6875		1.7
1.75	1.75	
1.8125		1.8
1.875		
1.9375		1.9
2.0	2.0	
2.0625		
2.125		2.1
2.1875		2.2
2.25	2.25	
2.3125		
2.375		2.3
2.4375		2.4
2.5	2.5	
2.625		
		2.6
		2.7
2.75	2.75	
		2.8
		2.9
2.875		
3.0	3.0	
3.125		3.1
		3.2
3.25	3.25	.
.	.	.
4.0	.	.
	.	5.9
	6.0	
		6.25
	6.5	
		6.75
	7.0	

NOTE: The British Standard recommends interpolation in steps of 0.05-inch between 1.5 and 6.0 inches, and steps of 0.1-inch above 6 inches, if intermediate sizes are required by exceptional circumstances.

compared with the inch. *Fig.* 2 shows how the pinion of *Fig.* 1 would have been dimensioned in France or Germany. However, there is very little hope that the metric system will ever be introduced into the Anglo-American engineering world because of the great deal of capital equipment and experience which is tied up in inch gages, screwing systems and standard parts. Apart from the convenience of the size of the unit in the metric system, many of the claims for superiority which are made by its protagonists are much exaggerated and certainly, from the ordinary everyday or household point of view, it may even be said to have several disadvantages.

It is well known that a metric micrometer is easier to read than an inch micrometer, but this advantage stems from the convenience of the unit size rather than from any basic advantage of the metric system itself. *Fig.* 3 illustrates this point. The metric micrometer is set at 16 millimeters and can be much more easily read than the corresponding inch micrometer set at the equivalent nominal dimensions of 5/8-inch or, say, 17/32-inch. The usual fractional conversion scale engraved on the micrometer in *Fig.* 3 serves to underline the point already made—that engineers still think in fractions but express themselves in decimals.

Fractional System Losing Ground

There have already been signs in certain sections of the aircraft industry both in America and in Britain of a move away from this fractional inch system. One attempt is the two-place decimal system or use of equivalent two-place decimal dimensions where practicable (e.g., 0.32 in place of 0.3125). In England, much use is made of the 1/10-inch unit, and the most refined system, reverting to Whitworth's proposal, makes use of a basic unit of 1/20-inch, that is 0.05-inch. It will be found that this unit which, incidentally, is of the same order of size as the millimeter, is an extremely convenient design unit and most work can be done in multiples of it. It has a great practical advantage that was realized by Whitworth—the half unit (i.e., 0.025-inch) corresponds with 1/8-inch steps.

Fig. 4 shows the typical pinion drawing already referred to, as it would be dimensioned in this "05" system. In the 32 dimensions of *Fig.* 1, 126 numerals or decimal places are required. The metric system dimensioning, *Fig.* 2, requires 58 numbers, or 46 per cent of the inch system; the 05 (1/20-inch) system uses 71 numbers, or 56 per cent of the American system. The 05 system is fundamentally not as good as the metric system from this point of view, but this cannot be avoided without rejecting the inch as the basic unit.

This tenth system is slowly gaining ground in Great Britain in certain companies. The first national standard making use of it is the British Unified Thread Standard for large sizes where there is at present no agreement with the United States. TABLE 2 gives details of the British Standard for Threads above 1.5 inches compared with normal American practice.

The basis of this 05 system is thus simple enough. All design work is laid out using 1/10 and 1/20-inch rules or, as preferred in some offices, on squared paper ruled in 1/20ths. In deference to existing stocks of tools, drills and cutters, common fractional diameters are used below, say, 1 or 1½ inches, although there would be no difficulty in providing 1/10 and 1/20-inch drills, reamers and milling cutters as stock items in many shops below this size. Important fits and smaller size dimensions, clearances, etc., are expressed as at present in decimal units except that the preferential subdivision of the unit of 0.05-inch is as follows: 0.1, 0.05, 0.02, 0.01, and 0.005. For normal lengths and diameters the step 0.02 is preferred to 0.025 although the latter has a special place in the particular case of 1/8-inch steps.

A subsidiary change in practice which could result from the introduction of this dimensional system would be a change in the method of expressing limits on drawings. Due to the complication of the present (fractional) unit when expressed in decimals, it is considered good practice in the inch countries to quote actual decimal sizes for limited dimensions: e.g., 1 7/16$\pm$0.0010 or 1.4385/1.4365. Metric practice, however, is different due to the convenience of the basic unit: e.g., 35mm$\pm$0.025 is never given as 35.025/34.975.

There are many arguments which can be put forward for the metric method, particularly with a standardized tolerance system and with production using gages as opposed to measurement, and it becomes practicable with the "05" system to do the same: e.g., 1.45$\pm$0.001. However, this change is not obligatory and might be a long time in becoming adopted; 1.451/1.449 is still better than 1.4385/1.4365.

Actual experience with the 05 system over a number of years has confirmed its great practicability for the designer and its convenience and suitability for the man in the shop. Its adoption throughout the United States would be a great step forward and one which would finally eliminate the question of adopting the metric system.

Barge Carries Hot Oil

A "thermos jug" barge transports lubricating oil stocks at high temperature from Houston, Texas to a terminal on the Mississippi River nine miles above New Orleans. Steel tanks in the 240-foot barge, built by Dravo Corp., Pittsburgh, are heavily insulated with Fiberglas to retard heat losses from the oil.

Fig. 1—In Assur's method of mechanism analysis, ternary links are arranged in line, with binary links attaching groups to an initial mechanism

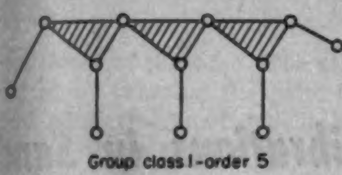


Fig. 2—New ternary links can branch off internal ternary links in Assur's system

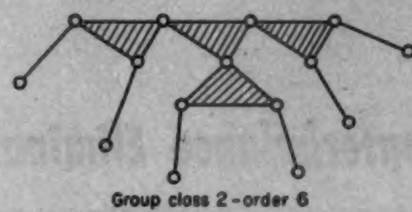
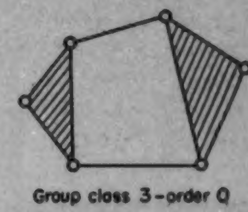


Fig. 3—Closed figures or contours are attached directly or by leads to cranks, links or frame of an existing mechanism



ARE THE RUSSIANS AHEAD IN *Mechanism Analysis*

By A. E. Richard de Jonge

OMISSION of references to Russian work on mechanism design in two papers[1, 2] recently brought forth complaints from a Russian professor. On being advised that very few recent Russian works were available here, he sent the author a number of textbooks and papers to prove the great advances made by Russian scientists in these fields. Information gathered from these and other sources that recently have become available here should be of value to the design engineering profession.

In a paper presented at Moscow in 1948[3], the author's correspondent discussed some of the Russian progress and laid claims of priority to several advances. Although some of these claims are exaggerated, it should be recognized that in the USSR numerous groups of scientists and a very large number of students are diligently at work in centers such as the Leningrad and the Moscow Technical Institutes, the Agricultural Institute, and numerous others, attempting to advance the science of mechanisms in its various branches.

The work of so many men in this field is bound to produce a multitude of papers. While some of this work is concerned only with details, there are numerous more general papers which should receive attention in this country. Unfortunately, many Russian publications have still not reached the United States so that a comprehensive review and appraisal of the Russian work is not yet possible.

Further, there is the difficulty and exorbitant cost involved in the translation of these works. In the

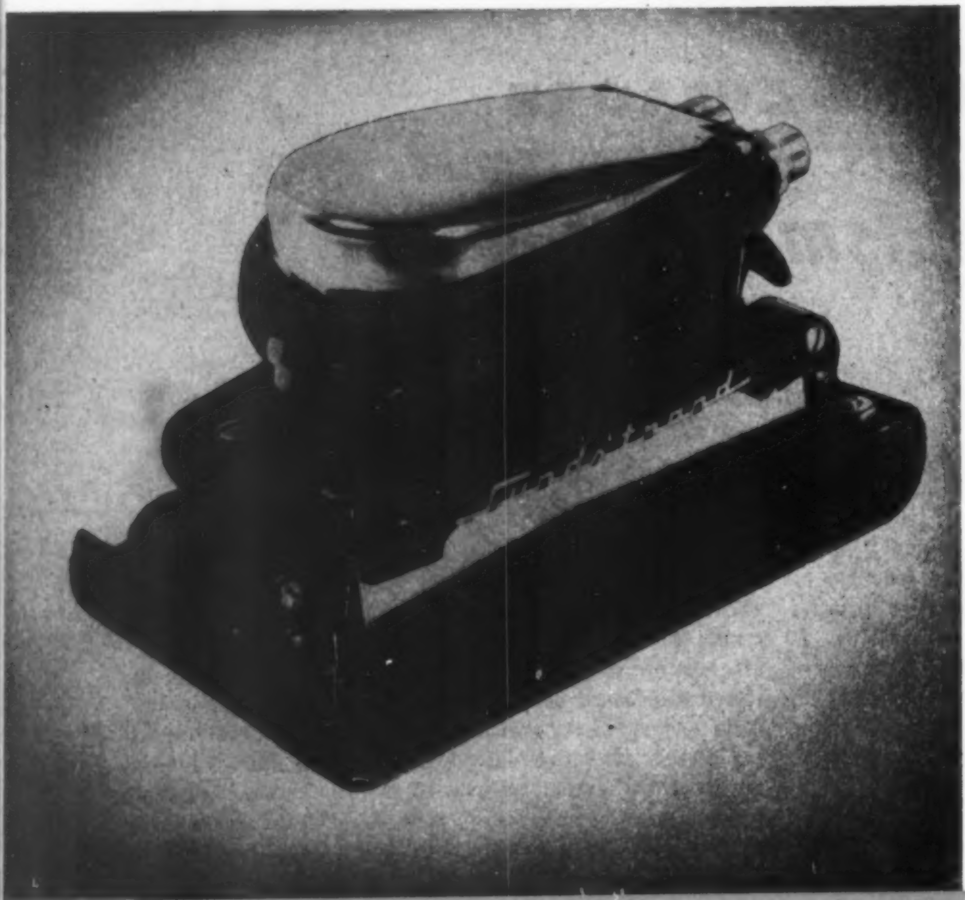
(*Continued on Page* 200)

[1]References are tabulated at end of article.

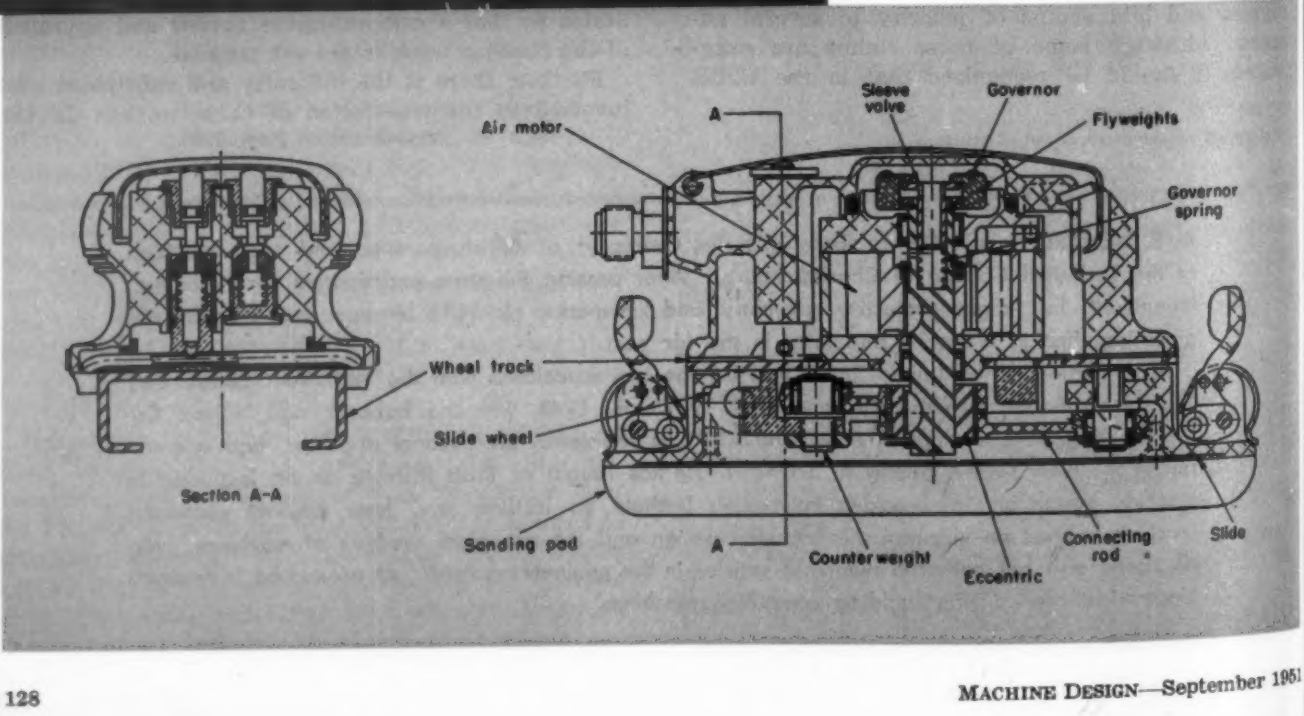
A. E. RICHARD de JONGE was born in Berlin, Germany, of British parents, and was educated at the Technical College of Charlottenberg. After passing the state examination for "Diploma-Ingenieur", he taught projective geometry and kinematics. In 1911 he went into practical engineering, first in Germany and later in the far east.

After coming to the United States in 1928, he was associated with the New York Edison Co., The Electric Bond and Share Co. and, from 1931 until 1948, with the Babcock and Wilcox Co. Mr. de Jonge is a member of ASCE and ASME, a registered professional engineer, and a member of the New York Academy of Sciences. He has taught at Pratt Institute as an instructor in machine design and at Brooklyn Polytechnic Institute as lecturer and later adjunct professor, teaching courses on kinematics in machine design and the graphical analysis of machines. Mr. de Jonge also has authored numerous articles in the engineering field. At present he is research kinematician for a firm building computing machines.

Counterbalance Eliminates Vibrations in Sander



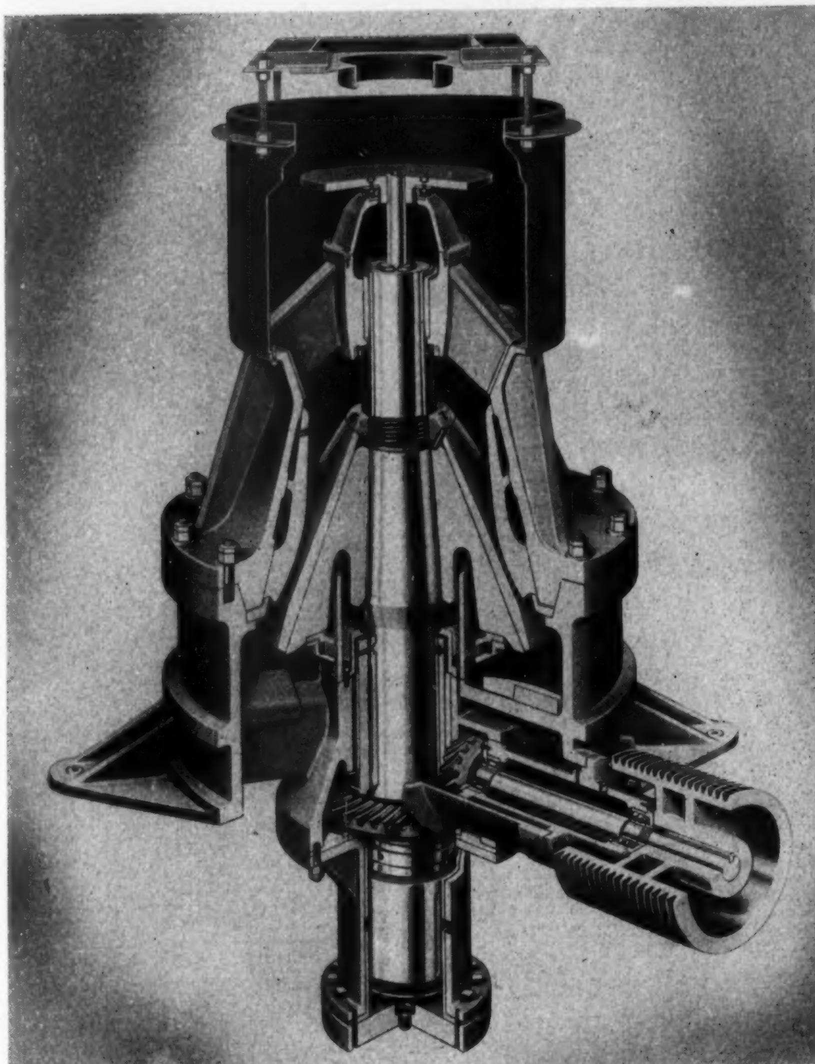
STRAIGHT-LINE sanding action of the Sunstrand Machine Tool Co. pneumatic sander, left, is counterbalanced to permit almost vibrationless operation at from 1500 to 3000 strokes per minute. The sander is powered by a balanced vane type air motor, drawing below, the speed of which is regulated by a governor. Flyweights actuate a spring-loaded sleeve valve which controls the air supply to the motor. Various speeds can be obtained by interchanging governor springs. A double-throw eccentric mounted on the output shaft of the motor drives the reciprocating mechanism through a connecting rod. The connecting rod drives a slide to which the sanding pad is attached. This slide is mounted on four wheels which ride in a track formed around the slide. To balance the slide, another connecting rod driving a counterweight is employed. This counterweight rides in the track within the slide and reciprocates in direct opposition to the slide to balance the

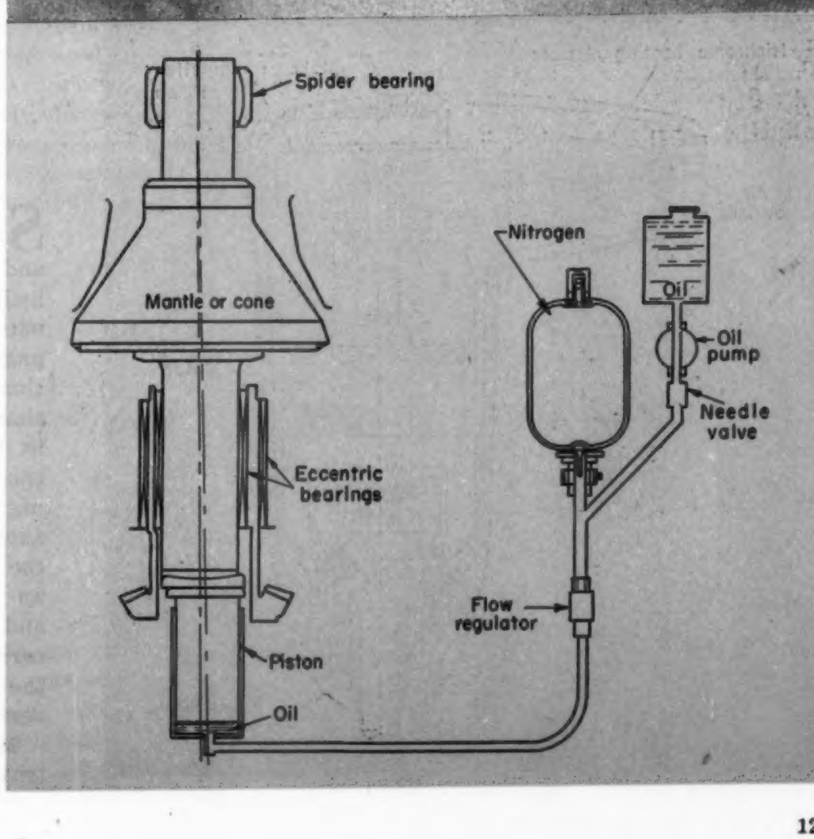


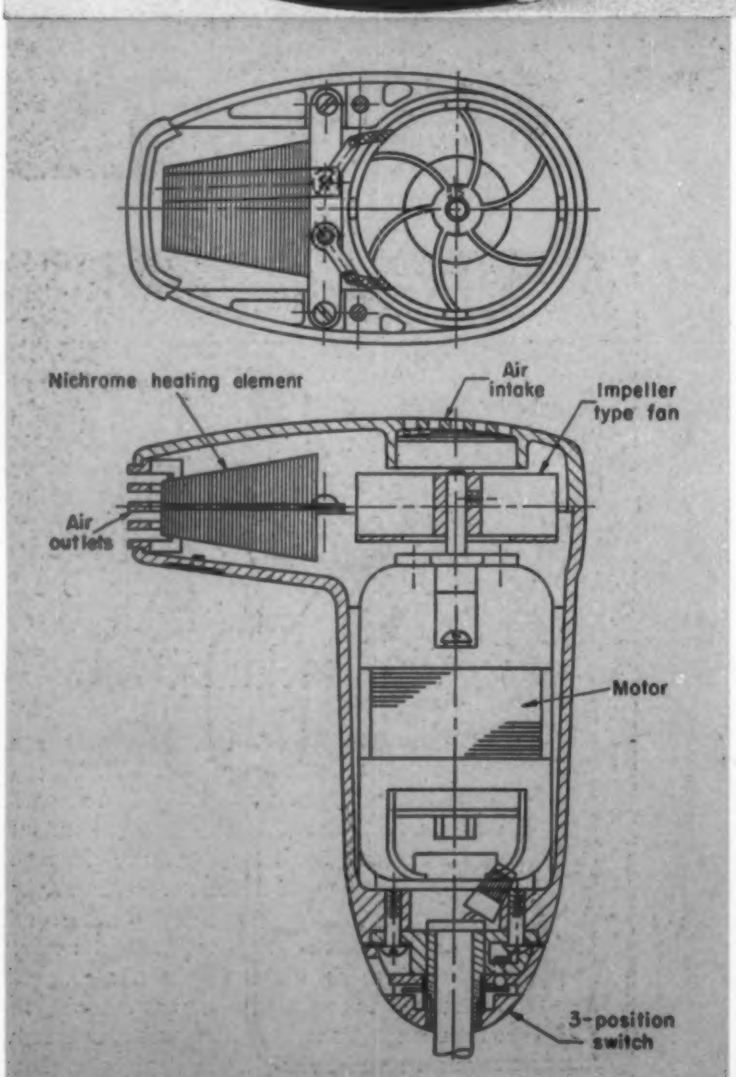
inertia forces of the slide. The sander is started by pressing the palm lever control with the hand which holds the sander, both air and water from the built-in water attachment being controlled by another lever. The lightweight sander, weighing 5½ pounds, requires from 5½ to 10 cfm of air, depending on operating speed.

Crusher Employs Hydraulic Reset

HYDRAULIC adjustment of the cone in the Allis-Chalmers Hydrocone crusher, right, permits quick and easy setting of the machine for various sizes and protects the crushing mechanism against damage from tramp iron or other uncrushable materials. Oil in a hydraulic jack supports the crushing cone assembly, drawing below right, the amount of oil below the piston determining the vertical position of the cone and therefore the size of the crushed material. An accumulator in the hydraulic system serves as an automatic reset when the cone is forced down by a steel or other uncrushable object. This accumulator consists of a neoprene rubber bladder inside a steel shell. The bladder is inflated with nitrogen to a pressure higher then the average pressures encountered during normal crushing. When foreign material enters the crushing chamber, oil pressure in the hydraulic jack will exceed the gas pressure in the accumulator, compressing the bladder, allowing part of the oil to enter the steel shell, and permitting the cone to lower and discharge the uncrushable object without damage to the machine, after which the pressure in the accumulator resets the cone to its original position.







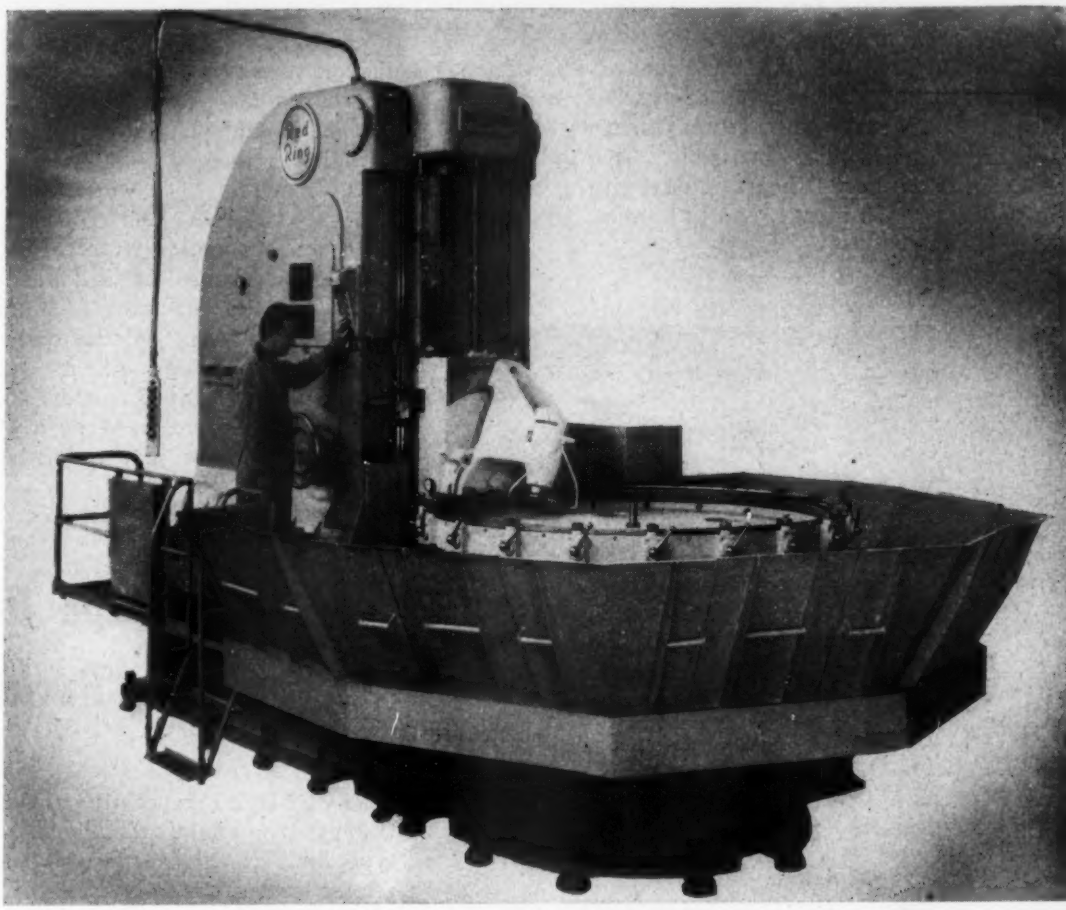
Plastics Permit Compact Dryer Design

DESIGNED for rapid hair drying or for other applications requiring a blast of hot or cold air, the A. C. Gilbert Co. dryer, left, shows the compact design and sleek appearance made possible by use of a molded plastic case. Only 5⅝ inches long, the dryer includes an integral universal motor and impeller type fan assembly mounted on self-aligning and self-lubricating bearings, drawing below, a three-position switch, and a Nichrome wire heating element with an automatic shutoff to prevent overheating. Chromium-plated air-exhaust grilles are molded in the case. The unit can be used for cooling if current to the heating coil is turned off.

Shaver Designed for Large Gears

SHAVING of internal and external spur and helical gears with face widths up to 40 inches and pitches to 100 inches is possible with the machine shown at the top of next page. The first machine of its type, the National Broach and Machine Co. Red Ring shaver is especially applicable to gears used in tanks, power shovels, mine hoists, large speed reducers, and marine drive units. Shaving is accomplished by the rotary crossed-axes principle, with the work gear driving the cutter. General design features include an independently driven rotary work table and a column which moves horizontally to carry the cutter head to and feed it into the work. The cutter head reciprocates in its vertical slide across the face of the work.

The column is provided with power rapid traverse in both directions to bring the cutter

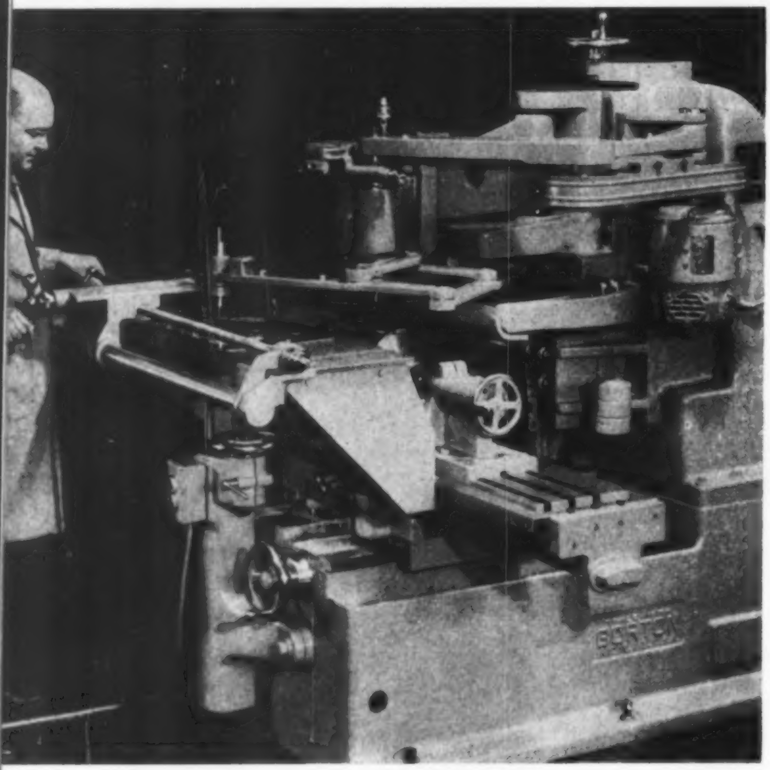


head approximately into cutting position and to retract it. Safety electrical controls automatically stop rapid advance of the column just short of engagement between cutter and work gear. Actual engagement is accomplished by a hand wheel which is also used to feed the cutter into the work during the shaving operation. The cutter head is adjusted angularly through a 30-degree arc to obtain any necessary crossed-axes setting. Initial adjustment of this setting is made with a vernier scale, the final setting by a built-in dial indicator.

Press Draws Cartridge Cases

FIRST hydraulic press for producing 105-mm cartridge cases under the current armament program, made by the Lake Erie Engineering Corp., is shown at the right. Produced for the Army Ordnance department and Navy Bureau of Ordnance, the 200-ton

press is being used for the first draw of cases from cold-drawn steel. The machine operates at a higher production rate and with greater accuracy of control than was previously possible. The press has a bed area of 30 by 30 inches, a daylight opening of 66 inches, a 48-inch stroke, and is powered by a 125-hp motor.



Pantograph Engraves Cylinders

COMPLETELY new pantograph machine, above, built by the George Gorton Machine Co., accurately mills, routs and engraves completely around rolls and cylinders. The machine is designed to fit the needs of several fields: paper converters and metal foil processors, where the product is printed, embossed or die cut from rolls; the wallpaper industry, where printing and embossing rolls are used; paper mills, which roll-in an all-over trade mark design; and the rubber industry, where rolls are used to create raised or reversed designs in rubber products. Ferrous or nonferrous metal and plastic rolls from 6 to 12 inches in diameter and up to 40 inches long can be handled in the machine. The workpiece is held between centers as on a lathe and movement of the tracer forward and backward automatically rotates the roll.

A unique feature of the machine is the absence of gears and the resultant elimination of backlash in the drive between spindle and roll. Correct speed of rotation for reproducing the master completely around rolls of any diameter, within the capacity of the machine, is provided by a built-in compensating mechanism which is set for each roll diameter.

Electric Tape Dispenser Speeds Packaging

PACKAGES are easily and correctly taped with the electric Dial-Taper shown below. A telephone type dial selects the desired length, starts the dispenser and stops the machine automatically after it has measured and cut off the moistened tape. To give a better seal, the moistening system heats water from the 1-quart reservoir before brushing it on the tape. The machine, made by Marsh Stencil Machine Co., handles tape rolls from 1 to 3 inches wide and up to 9 inches in diameter.

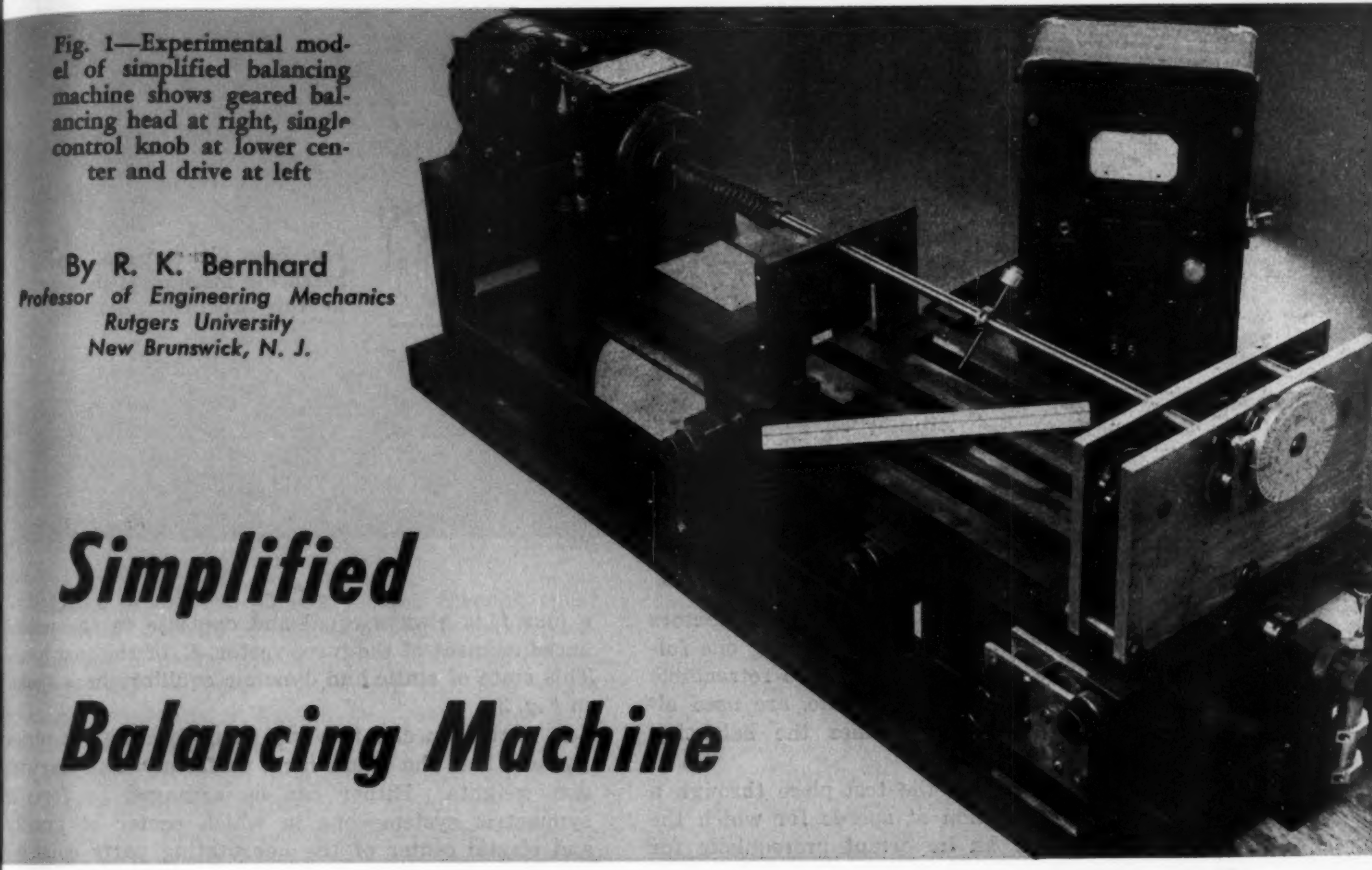


Fig. 1—Experimental model of simplified balancing machine shows geared balancing head at right, single control knob at lower center and drive at left

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Simplified Balancing Machine

MANY balancing machines consist of more or less complicated electro-mechanical transducers.[1-6] Maintenance and often the operation of these transducers requires trained personnel. The main purpose of the development described in this article was the design of a balancing machine which avoids these difficulties.

One of the well known principles used in balancing machines is the compensation of existing unbalances in the test piece by means of controlled unbalances. These artificial unbalances are produced in the balancing head and are made opposite in magnitude and direction to the existing unbalance in the piece. In this machine, the artificial unbalances are excited by four eccentrically supported rotating disks. Relative position of these disks is controlled by the setting of one knob only, two concentric scales automatically indicating magnitude and direction of the compensating unbalance and, consequently, magnitude and direction of the required correction weights.

In building the machine only standard, easily available parts were used. Various gear trains, consisting mainly of one or more identical epicyclics as controlling elements, form simple mechanical couplings. The epicyclic units could be replaced by differential gear assemblies.

The machine may be used at any speed—below, above, or at resonance of the vibrating cradle. Hence the required correction weights can be determined at the exact operating speed of the test piece. Furthermore, the testing procedure does not require a change in position of the test piece. Finally, most parasitic force components in the balanced stage are avoided.

The general set-up, shown in *Fig.* 1 and the sketch of *Fig.* 2, consists mainly of three parts: cradle, drive, and balancing head. In *Fig.* 1, a known unbalance has been substituted in place of the test piece for calibration purposes.

CRADLE: The cradle is of the rigid-frame type, supported by springs. The fulcrum is adjustable and can be moved lengthwise along the bed into either of two correction planes, b_1 or b_2. If any vertical motion of cradle is blocked with the fulcrum in plane b_2, as shown in *Fig.* 2, the correction weight for plane b_1 can be determined with respect to magnitude and direction. Thus, the compensating unbalance reading at the balancing head must be multiplied by the ratio $(A + B)/B$ where A is the horizontal distance between balancing head and correction plane b_1, and B is the horizontal distance between the two correction planes; the required correction weight in plane b_1 has the same phase angle as the compensating unbalance at the head.

For correction in plane b_2, the fulcrum is moved into plane b_1. The compensating unbalance reading then must be multiplied by the ratio A/B. Here the required correction weight in plane b_2 is 180 degrees out of phase with the compensating unbalance at the balancing head. Making the distance A equal to the

[1]References are listed at end of article.

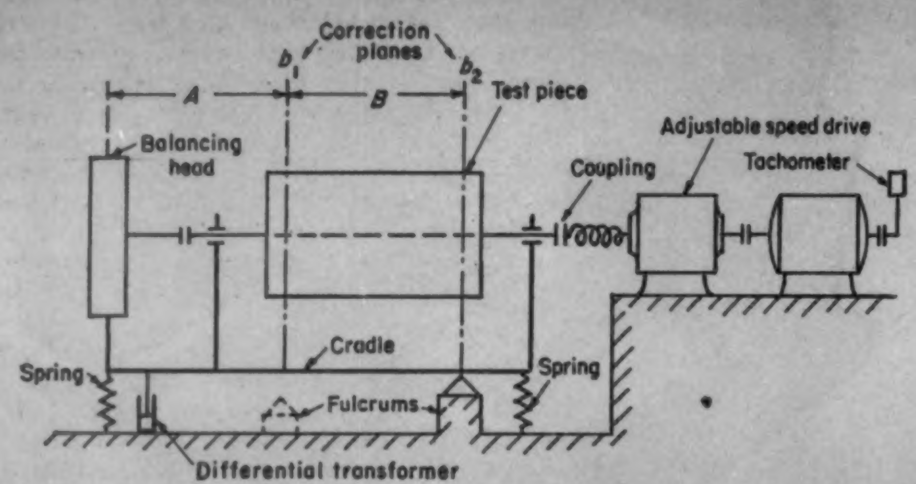


Fig. 2 — General setup of balancing machine is shown in this schematic drawing

distance B, *Fig.* 2, reduces the multiplication factors to 2 and 1, respectively. Instead of moving one fulcrum from correction plane b_1 to b_2, two retractable fulcrums, one in each correction plane, are used alternatively, which further simplifies the balancing procedure.

An electric motor drives the test piece through a variable speed transmission at speeds for which the specimen is designed, an important prerequisite for accurate balancing.

BALANCING HEAD: The balancing head, at the right of *Fig.* 1, is rigidly mounted on the cradle and driven through a coupling at the same speed as the test piece. Basic principle governing the balancing head is demonstrated in *Fig.* 3 for one half cycle (180 degrees). Four centrifugal force vectors of the same magnitude, a, b, c, and d are produced by four eccentrically supported disks rotating at the same speed and in the same sense. The resultant component, e, of the two left vectors, a and b, and the resultant component, f, of the two right vectors, c and d, are at all times equal in magnitude and direction.

The reaction, R, to the resultant force vector produced by the two components, e and f, follows the equation:[7]

$$R = \frac{4W}{g} r \,(2\pi n)^2 \cos \frac{\theta}{2}$$

where

W = Weight of each of the four rotating eccentric masses, lb

r = Eccentricity of each weight, inches

g = Gravity acceleration, in. per sec^2

n = Speed of weights and test piece, rps

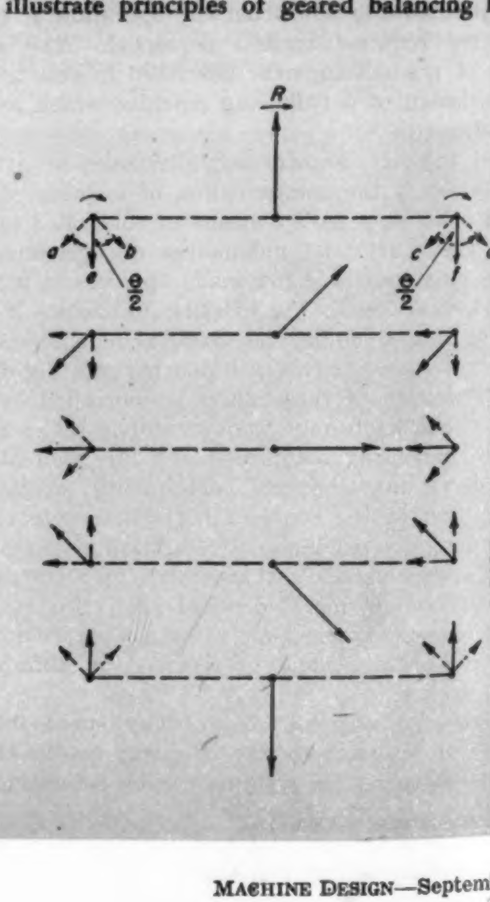
θ = Angle between the two weights a and b and between c and d on each shaft, degrees.

Because of the cosine function ($\cos \theta/2$) the maximum sensitivity is obtained when θ approaches 180 degrees, thus facilitating the adjustment for smaller unbalances, a particular advantage of this arrangement.

To produce static and dynamic equilibrium, the two resultant force vectors, e and f, have to be adjusted with respect to magnitude and direction in such a way that the unbalanced moment of their sum, e plus f, is always equal and opposite to the unbalanced moment of the force vector, R, of the test piece. This state of static and dynamic equilibrium is shown in *Fig.* 3.

A control mechanism with four rotating eccentrics tends to load the cradle more uniformly than one with two weights. Either can be arranged to form a symmetric system—one in which center of gravity and elastic center of the nonrotating parts coincide. This coincidence and the above mentioned arrange-

Fig. 3—Force vector diagrams of one half cycle illustrate principles of geared balancing head



ment of the rotating force vectors are essential in order to reduce parasitic vibrations, thus facilitating the balancing procedure.

To increase (or decrease) the magnitude of the resultant moment of the force vectors, e and f, the angles θ between the two component force vectors a and b and between c and d have to be decreased (or increased). To change the direction of the resultant moment of the force vectors, e and f, the direction of all four component force vectors, a, b, c and d, has to be changed simultaneously in the same sense.

Interlocking gear trains which allow this independent change of magnitude and of direction of the resultant force vectors while the machine is in operation are combined in the balancing head, *Fig.* 4. Four interchangeable, eccentrically supported rotatable disks are connected through two epicyclic gears. The four disks rotate always with the same speed and in the same sense as the driving shaft and the test piece.

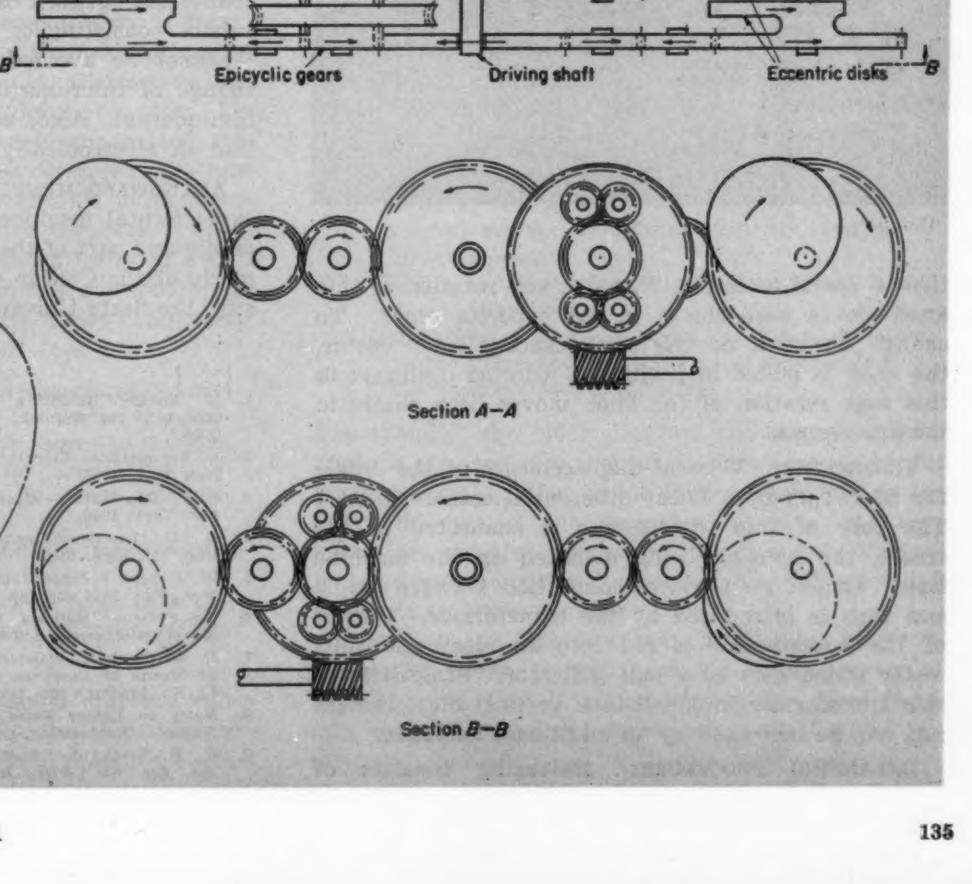
Rotation of the two planetary cages through equal angles in an opposite direction produces an increase or decrease in *magnitude* of the resultant centrifugal compensation vectors; rotation of the two cages through equal angles but in the same sense produces a change in *direction*.

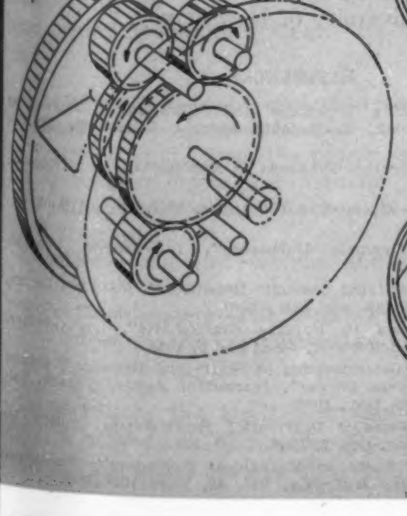
Correction Weight Indicator: Once static and dynamic equilibrium is obtained, magnitude and direction of the required correction weights, either in plane b_1 or in plane b_2, can be read directly on the two concentric indicator dials, *Figs.* 1 and 5, mounted in front of the balancing head. The inner dial, *Fig.* 5, is mounted on the shaft of another epicyclic and the outer dial is connected through this planetary gearing to shafts leading to the planetary cages shown in *Fig.* 4. Hence, the inner dial (indicating the direction of the correction weights) and the outer dial move simultaneously and through the same angle if the cages of both epicyclics of *Fig.* 4, are rotated in the same sense. When the two planetary cages, *Fig.* 4, are moving in opposite sense, only the outer dial (indicating the magnitude of the correction weights) rotates while the inner dial remains at rest.

Control Mechanism: Purpose of the control mechanism is to adjust the four eccentric disks to such a position that static and dynamic equilibrium is obtained. In other words, the vibrating system including cradle, test piece and balancing head must not oscillate when the test piece is rotating at its operating speed.

Fig. 6 represents this control mechanism, which is rigidly mounted on the machine base. The worm-gear drives of the two planetary cages of the balancing head, *Fig.* 4, are connected by light-weight flexible shafts with the two shafts of the control mechanism, *Fig.* 6. This flexible connection does not introduce any appreciable parasitic vibrations into the oscillating system. To change magnitude of the compensating force vector, the knurled knob is pushed into posi-

ig. 4—Schematic diagram of alancing head, right, shows implicity of gearing. Epicyclics, below, are both driven n same direction from driveshaft; worm wheels in epicyclic rains connect with flexible hafting leading to control nob for adjusting magnitude nd direction of force vectors





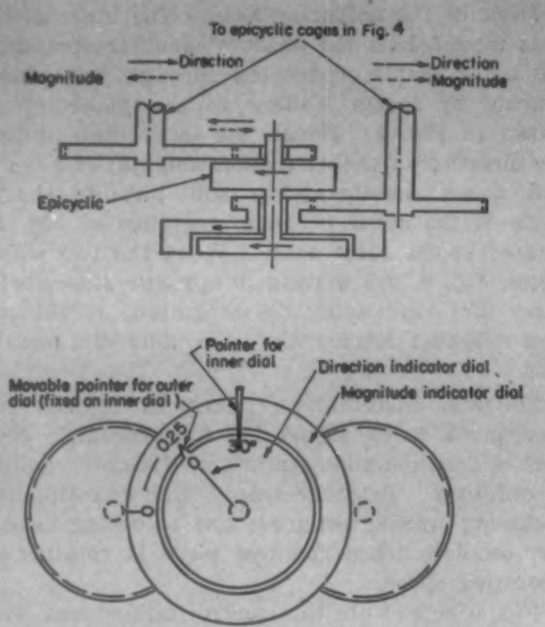
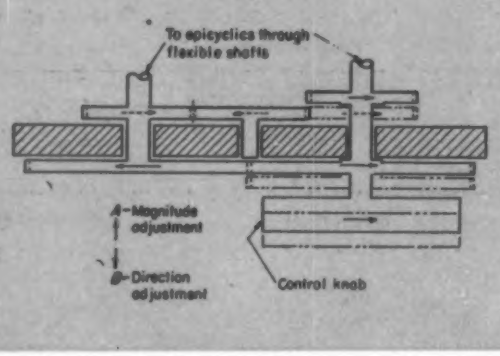


Fig. 5 — Above — Direction indicator (inner dial) and magnitude indicator (outer dial) are driven from a mechanism connected to the two epicyclics shown in *Fig. 4*

Fig. 6—Below—"In" position of control knob adjusts magnitude of compensating unbalance forces, "out" position adjusts direction of balancing forces



tion *A* (solid outline in *Fig.* 6); any rotation of this knob moves both shafts in the opposite sense. To change direction of the compensating force vector, the knob is pulled in position *B* (dotted outline); in this case rotation of the knob moves both shafts in the same sense.

VIBROMETER: Vertical displacements of the cradle are picked up by a linear differential transformer.[8, 9] The core of this transformer is connected to the cradle, the housing being mounted on the machine base. Hence, no physical connection between cradle and base is introduced by the transformer. Output of the transformer is fed into an electronic voltmeter which acts as a null indicator. Sensitivity of this transformer is 0.0001-inch vertical displacement and can be increased by an additional amplifier.

BALANCING PROCEDURE: Balancing consists of three steps: (1) The specimen is inserted, the fulcrums in the desired correction plane b_2 are adjusted and the machine brought up to the operating speed of the test piece. (2) The control knob, *Fig.* 6, is rotated manually until the electronic voltmeter indicates zero, using alternately the control knob in its position for magnitude, *A*, and direction, *B*. The two scales on the dials, *Fig.* 5, show direction and magnitude of the required correction weights for plane b_1. (3) The same procedure is repeated with the fulcrums adjusted in correction plane b_1. Dial readings indicate direction and magnitude of the required correction weights in plane b_2. Neither a relocation nor an interruption in the rotation of the test piece is required.

For steps (2) and (3), the previously mentioned multiplication factors, and for step (3) the 180-degree phase shift, have to be considered.

The experimental model, *Fig.* 1, has the following characteristics: Unbalance range, from 0 to 5.5 in.-oz; operating speed range, from 10 to 400 rpm; accuracy ± 0.1 per cent; and sensitivity, ± 0.0001-inch displacement amplitude.

The balancing machine has several advantages. The required correction weights can be determined at the operating speed of the test piece, regardless of whether the balancing machine is used below, above, or at resonance. Also, the test piece remains in the same position for the determination of the correction weights in both planes. The operator has to adjust one control knob only to determine magnitude as well as direction of the correction weights. Since the vibration indicator yields qualitative values only, calibration requirements are reduced to a minimum. Finally, all complicated transducer systems, quantitatively measuring electronic devices, cams, slip rings, clutches, etc., are eliminated.

Disadvantages of the equipment are that a physical connection between balancing head and control mechanism—consisting of two lightweight, flexible shafts—cannot be avoided, and the balancing requires a change of fulcrums depending upon the two correction planes. Also, accuracy obtainable is less than that of electronically controlled balancing machines.

ACKNOWLEDGMENT: The balancing head of this experimental machine was built by R. C. Braen, the cradle and part of the drive by D. F. Ferris, both formerly of the College of Engineering, Rutgers University, the State University of New Jersey.

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Dynamic Response of Hydraulic Systems

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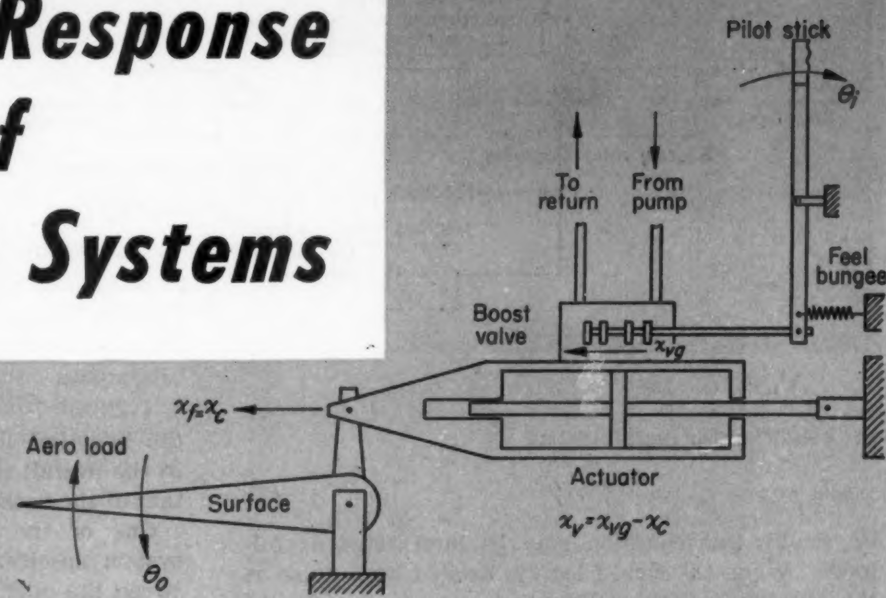


Fig. 1—Schematic diagram of hydraulically powered control system

DYNAMIC response of a hydraulic control system may be specified in terms such as stability, speed of response, error, damping, and time lag. In order to design a system to meet specified values of these response characteristics, there are certain considerations which are common to hydraulic control systems in general. These considerations include the response characteristics themselves, the physical properties of the hydraulic system, the block diagram, etc. In this article the salient features of several of these considerations are discussed. A simplified hydraulic aircraft surface-control system is used for illustrative purposes.

The control system shown schematically in *Fig.* 1 incorporates an artificial feel and is powered by an open center hydraulic system. Its major components are:

1. Input system—pilot stick and associated linkage
2. Boost valve—control element to meter the flow and pressure from the power source to the load
3. Servomotor—hydraulic actuator converting hydraulic power into mechanical power to drive the output load
4. Output—controlled surface and the aerodynamic load
5. Feedback system—follow-up which feeds back the output x_c for comparison to the input motion x_{vg}.

In operation, the stick is deflected and the valve spool is moved, as shown in *Fig.* 1. The displacement of the spool meters flow and pressure to the actuator. Pressure and flow move the actuator and surface against the aerodynamic loading. As the actuator moves, the valve body moves in such a direction as to open the valve. The final position of the spool relative to the valve body is dependent on the surface loading.

For convenience and simplicity, the control system is redrawn as a block diagram in *Fig.* 2. In this diagram the following correspondence to *Fig.* 1 exists.

1. Block μ_i is the gearing ratio between stick deflection and spool displacement
2. Blocks μ_m and μ_o represent hydraulic system, actuator, surface, structural elasticity, and aerodynamic loading
3. Block μ_f is the gearing ratio between actuator and boost valve body
4. Comparison device—the spool position x_{vg} relative to the valve body position x_c—is represented by the cross enclosed in the circle.

Functionally, the block diagram shows that a stick angle is changed into a spool displacement x_{vg} by the gearing ratio μ_i. The spool displacement excites the hydraulic system, the structure, surface, and aero load. An actuator displacement x_c results. The actuator displacement is fed back to the valve tending to reduce the valve opening.

STABILITY AND PERFORMANCE: Application of servomechanism theory to the closed-loop block diagram of *Fig.* 2 shows that it may be unstable. That is, it may chatter, buzz, hunt, motor, etc.—all of which are forms of instability. The theory further prescribes

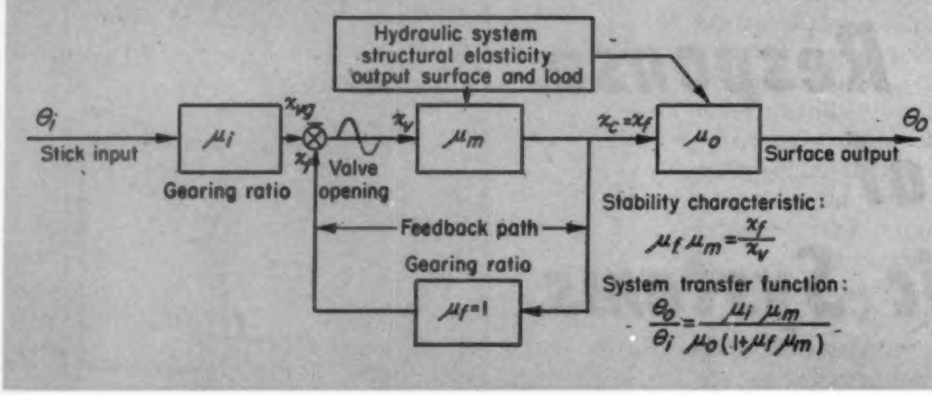


Fig. 2 — Block diagram for control system in *Fig.* 1, showing characteristics

the condition for instability as,

$$\mu_f \mu_m = -1 \quad (1)$$

Physically this equation may be interpreted as follows: When the closed loop is excited by a pulse at the boost valve (the solid curve at x_v in *Fig.* 2) the pulse travels through the hydraulic system, actuator, etc. and returns to the valve through the feedback path. For a certain system time lag, the returning pulse will arrive at the valve just as the initial pulse becomes zero. It will also be reversed in direction (the dotted curve at x_v in *Fig.* 2). This condition of time lag results in the minus sign in Equation 1. If, with this time lag, the amplitude of the returning pulse is equal to the initial pulse, unending oscillation occurs as the cycle is repeated. A divergent oscillation occurs when the amplitude of the returning pulse is greater than the initial pulse at the valve.

Closely associated with the stability of a system are two basic performance characteristics, the system time lag and the system error. System time lag is primarily a measure of the control system's speed of response. It is an indication of the amount of elapsed time between a stick deflection and a corresponding surface deflection. Time lag may be defined in several ways. It is essential, however, that the time lag definition be consistent in order to establish a basis of comparison. The dynamic response shown in *Fig.* 3 illustrates two time lags. One occurs because the pilot takes a finite amount of time to move the stick to some desired position. The second is due to the dynamics of the boost system.

If the pilot were capable of moving the stick with infinite acceleration and the boost valve spool did not bottom, the stick would follow the ideal step input curve shown in *Fig.* 3. However, the pilot force is limited; the linkage system has inertia, damping and elasticity; and the spool stroke is small. These factors combine to result in the time lag T_p. This time lag is defined as the time required for the stick to reach 95 per cent of its equilibrium position.

With the actual stick input of *Fig.* 3, the controlled surface reaches 95 per cent of its equilibrium position in T_s seconds. Time lag of the boost system is defined as the difference in time between the 95 per cent position of the stick and the 95 per cent position of the surface, i.e., $(T_s - T_p)$. A comparison of the two time lags shows that the pilot contribution to the overall time lag T_s is substantially larger than that of the boost system.

One of the requirements for a powered control system specifies a static, no-load gearing curve between the pilot stick position and the position of the surface. The actual position of the surface for a given stick position may not correspond to the gearing curve requirement. The difference between the desired surface position and the actual surface position is the system error. In *Fig.* 3, the system error is shown as the difference between the stick position and the surface position. The stick position, in this case, is representative of the static, no-load position of the surface.

PHYSICAL CONSTANTS OF THE SYSTEM: Up to this point, the control system has been isolated, a block diagram was drawn, and the significance of stability, time lag, and error have been discussed. Another step is necessary before any detailed mathematical study can be made of the control system. The block diagram of *Fig.* 2 must be described in terms of the physical properties of the combined hydraulic-mechanical-aerodynamic system.

As was stated previously, the blocks μ_i and μ_f are gearing ratios. Although the mechanical linkages have inertia, damping and elasticity, these properties are neglected in the first approximation. The blocks μ_m and μ_o are somewhat more complicated and are expanded into the electrical circuit of *Fig.* 4. It is an equivalent electrical circuit which has physical properties equivalent to the powered control of *Fig.* 1. The correspondence between the actual system and the electrical circuit is as follows:

1. The open-center system constant-displacement pump is replaced by a constant-current source
2. Hydraulic tubing and fluid, which have distributed fluid resistance, inertia and compressibility, are replaced by an equivalent T-network which has resistance, inductance, and capacity
3. Output load consists of the surface inertia, an effective structural elasticity, actuator leakage, and an equivalent aerodynamic loading. Surface inertia and aero spring load are replaced by an inductance in series with a capacity. Effective structural elasticity is a capacity in parallel with the surface inertia and aero spring. Leakage across the actuator piston is shown as the

by-pass resistor across the combined face-aero load

4. Elasticity of the fluid in the actuator is represented by a capacity on each side of the output load
5. The variable by-pass resistor replaces the boost valve. Flow through the variable resistor is dependent on the pressure drop across the valve and the position of the valve spool.

If the boost valve is not mounted on the actuator, additional T-networks may be required for the tubing between the valve and actuator.

CALCULATING STABILITY AND PERFORMANCE: Several methods may be applied to the problem of determining stability and performance. These methods include frequency response, transient response, root locus, Routh's criterion, analog and digital computers, etc. All of these methods can be useful during the synthesis, or analysis, of a system. For illustrative purposes, the frequency and transient responses of the control system are used.

Determining Lag and Error

One of the objectives of the frequency response method is to determine how the pulse (previously described in the discussion of *Fig.* 2) returns to the starting point. This is done by calculating the response of x_f to a sinusoidal excitation at the boost valve, i.e., x_v. The excitation amplitude is constant and the frequency is varied through a desired range. If at some frequency the conditions of Equation 1 are met, the system is unstable. For a stable system, the frequency response data obtained during the stability calculation may also be used to determine the system time lag and error. However, a transient response calculation provides results which may be related directly to actual use and operation of the control system. In the transient response, the closed loop of *Figs.* 1 and 2 is excited at the stick with a step input, a ramp input, or an input such as is shown in *Fig.* 3. The response of the surface to the input may then be calculated to provide the system time lag and error data previously described.

Calculation of stability and performance consists of four steps:

1. Differential equations describing the dynamics of *Fig.* 4 are written. These may be obtained by the application of standard techniques of circuit analysis
2. Differential equations are then expressed in terms of the complex frequency variable jw or the Laplacian operator s
3. Equations obtained in step 2 are solved for the open-loop stability characteristic and a closed-loop transfer function
4. Stability and performance can be determined by using one of the methods previously discussed.

The open-loop stability characteristic is the ratio x_f/x_v expressed in terms of the system constants and jw. *Fig.* 5 shows the ratio x_f/x_v plotted in polar form. The two solid curves are experimental loci and the dotted curve is the calculated locus. Agreement between experimental and calculated results is quite good.

Application of Equation 1 to *Fig.* 5 shows that curve A is unstable. That is, the locus encloses the

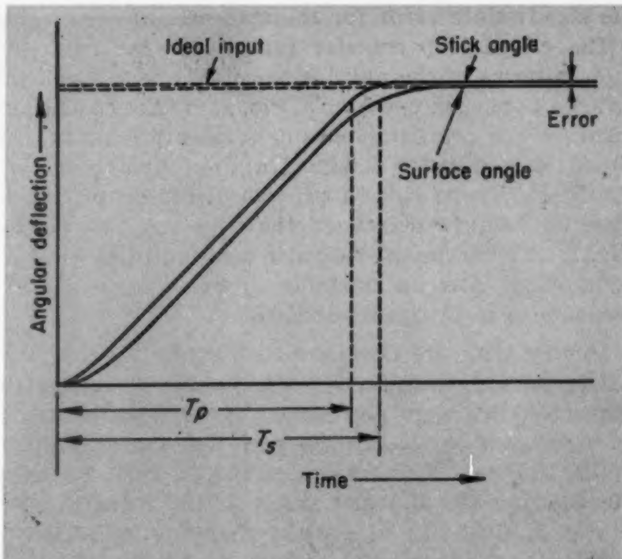
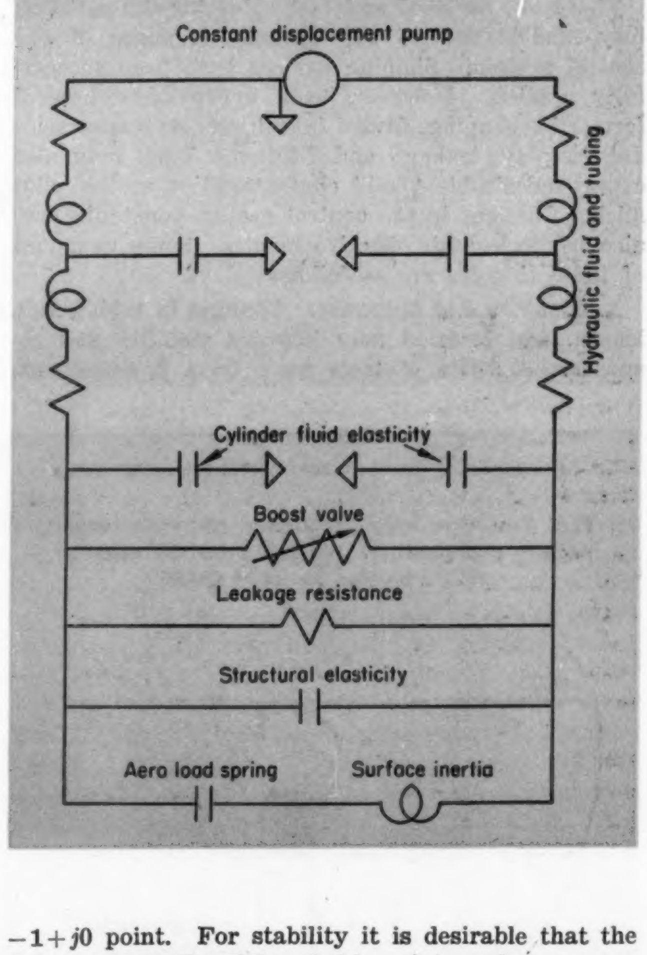


Fig. 3—Above—Response of system, showing time lag for initial signal and lag of system

Fig. 4 — Below — Equivalent electrical circuit for analyzing system characteristics



$-1+j0$ point. For stability it is desirable that the curve pass to the right of this point, such as curves B and C. When the locus passes to the right of the $-1+j0$ point, the distance between the locus and point may be used to determine the amount of overshoot and the speed of response of the control system. Magnitude and direction of the curve, as zero frequency is approached, may be used to determine

the steady-state error for the system.

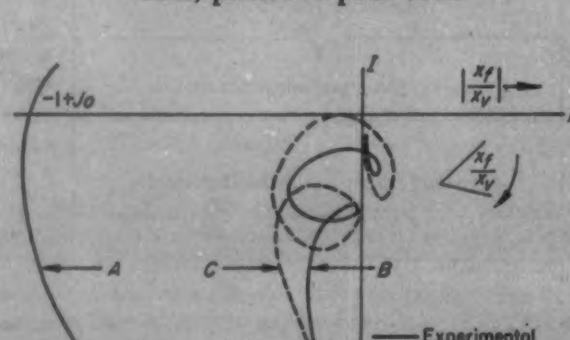
The closed loop transfer function is the ratio of θ_o/θ_i in terms of the physical constants of the system and the Laplacian operator s, *Fig.* 2. If the Laplacian form for the transient input θ_i is substituted into the closed loop transfer function, a time history of the response may be calculated. The time history may then be used to determine the time lag and error, *Fig.* 3. The transient response also indicates system instability. For an unstable system, the transient response is a divergent oscillation.

MODIFICATION OF DYNAMIC RESPONSE: In the preceding section, methods for determining the response characteristics were discussed. These same methods may be used to modify the response characteristics of the system. Modification of the response consists of changing the size and shape of the locus plotted in *Fig.* 5. This may be done by changing the physical constants of the control system, or by the addition of shaping elements to the control system. When the changes or additions are made, new frequency and transient plots are made until the desired results are obtained. The root locus method and the analog computer are very useful simplifications during this stage of the design procedure.

There are no hard and fast rules for the satisfactory modification of the dynamic response of the control system. Shaping devices have been successfully applied. However, in a hydraulic-mechanical form, the shaping device is subject to inaccuracies due to play, leakage and friction. They may also cause undesirable "feel" characteristics at the pilot stick. Changes in the control system constants may also be made with effective results. Some examples of these changes are as follows:

1. *Stability and Response:* Changes in tubing size, length, and location may improve stability and response. A series of tests made on a powered control system showed that for the same overall length of tubing, the system was unstable when the tubing was installed between the valve and actuator. The system was stable when the same tubing was installed between the pump and valve.

Fig. 5—Open loop frequency response, comparing experimental with theoretical calculations, plotted in polar form



2. *Resonance:* An inspection of the output circuit in *Fig.* 4 shows that two resonant conditions may occur. A series resonance between the surface inertia and the aerodynamics and a parallel resonance between the structural elasticity and the combined surface inertia and aerodynamics. Changes here would have to be made in the preliminary design stages. Increasing the structural rigidity, reducing the surface inertia, and changes in the surface size and shape all tend to alleviate the resonant conditions.

3. *Valve Characteristics:* Boost valve characteristics may also be altered. The boost valve has two important characteristics: The flow rate per unit stroke at a constant pressure drop, and the flow rate per unit pressure drop at a constant spool position. A reduction in the first characteristic results in shrinking the locus of *Fig.* 5 until the curve passes to the right of the $-1+j0$ point. Changes in the second characteristic produces varying results. Tests have indicated that reducing the flow per unit pressure drop improves stability. Further tests have shown that increasing the flow per unit pressure drop is destabilizing up to a certain point; further increases result in stability again.

4. *Feedback Gain:* In *Fig.* 2 and in Equation 1, it can be seen that the feedback gain is a multiplier in the stability characteristic. It follows that if the value of μ_f is decreased, curve A of *Fig.* 5 may be reduced in size and made stable.

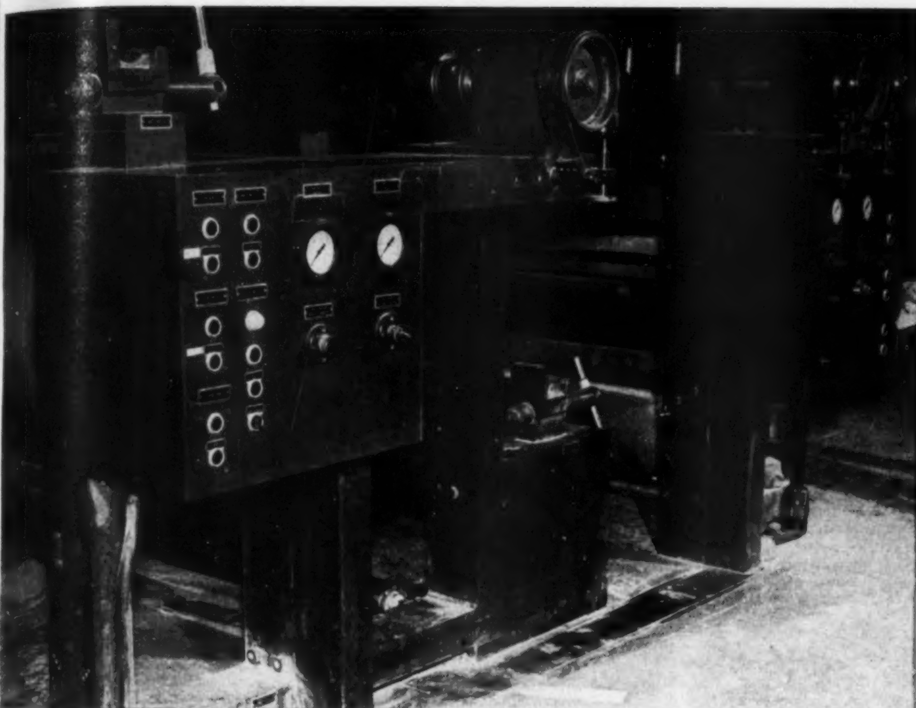
In conclusion, it seems appropriate to describe a series of tests that were made recently on a powered control system. These tests emphasized the importance and necessity of a design procedure which includes consideration of the system dynamics.

Stability Is Influenced by Tubing Length

An open loop stability characteristic was obtained for a control system which included fifty feet of metal tubing and two feet of flexible hose, with tubing and hose installed between the pump and valve. The system was stable. Length of the metal tubing was then reduced to ten feet with the flexible hose still installed and the tests showed this second configuration to be unstable. The two feet of flexible hose was then removed, and the test repeated. This third configuration was more unstable than either of the others.

Although the last configuration tested may have been desirable because of the savings in weight, cost, and reduced line losses, an analysis similar to the one discussed in this paper would have shown that the savings obtained by reducing the tubing length were more than offset by the resulting unstable response.

The author gratefully acknowledges the advice and suggestions of Mr. William R. Monroe, supervisor of the servomechanism research group, North American Aviation Inc., in the preparation of this article.



By Ransom Tyler
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Electric and hydraulic controls for this processing machine are mounted in the same cabinet but are completely separated by a wall. Piping is contained in rectangular raceways and trenches

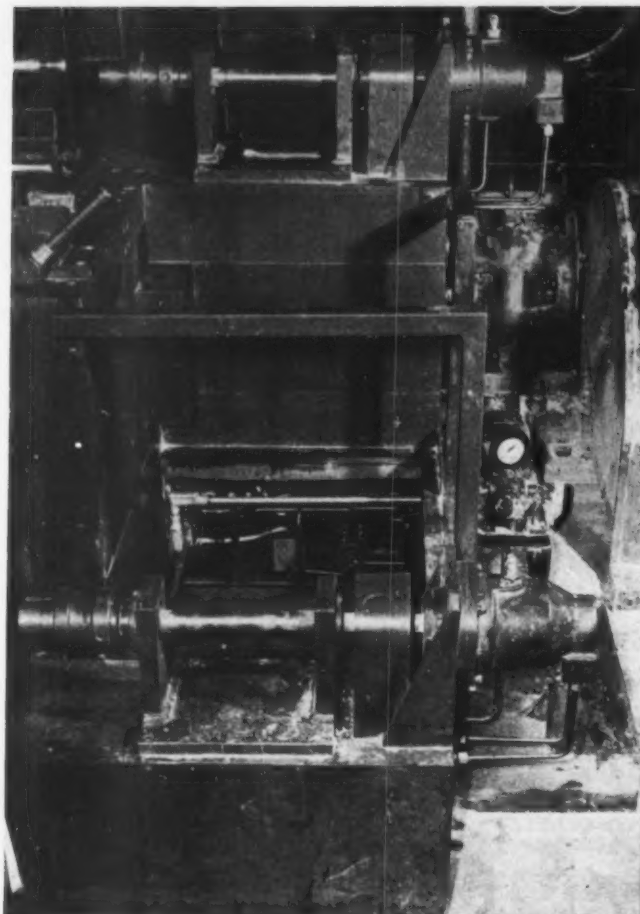
Protecting HYDRAULIC CIRCUITS *against fire hazards*

OCCASIONALLY a fire in a die casting plant, a forge shop, or a foundry points out the danger when hydraulic oils are exposed to high temperatures. A close investigation, however, will usually show that inadequate piping design, careless repairs, or neglect was really responsible for the trouble. While such fires are not a common occurrence, even once is too often if it could have been avoided.

It is natural, first, to ask about the use of fireproof hydraulic oils. However, there is not yet an approved fireproof oil even for use in airplanes. No doubt there will be such a fluid eventually but, until one is developed and produced at a reasonable cost, all possible precautions should be taken to assure that the oil is kept in the system.

How should a hydraulic system be designed for a hazardous area? A tip may be taken from the electrical engineer. Codes, which have the force of law, require the insulated wire to be enclosed in a metal protecting conduit which shields it from damage and, in case of leakage, conducts the leakage current to ground. A similar code would be effective for oil piping in hazardous places. The oil enclosed in strong piping would be run through raceway or conduits which would shield it from damage and, in case of leakage, would conduct the leakage oil to the waste pit. All controls would be enclosed in cabinets or on panels. This ideal has been achieved, wholly or in part, in many installations throughout the country. The illustrations show industrial processing machinery which has been equipped with several hydraulic drives. All controls have been enclosed in cabinets or on panels and all piping has been taken to these panels through sheet metal ducts which can be opened for inspection or repair.

For the engineer, who has the problem of designing a new, self-contained machine—such as a die casting machine or a forging press—that will be used with molten or hot metal, a critical analysis with respect to fire hazard may disclose danger spots which can be corrected easily. His concern in producing a safe machine should start with the initial design of the oil circuit. Simplicity should be the key note. The equipment selected should have the auxiliary valves and controls built integral with the fluid-power unit so as to eliminate most of the external piping and fittings. All pilot valves should be en-



Drive side of machine. The only exposed piping is the short lengths to the hydraulic motors shown at right. The piping is brought from the compartment through bulkhead fittings. Valves and piping are covered by a floor plate in the center foreground, forming an operator's platform

closed in compartments and all pilot piping should be shrouded in raceways. All the power piping should be steel with welded, flanged connections to the cylinders. The entire design should avoid inaccessible pockets in which dirt and oil may collect.

The circuit design should be critically examined for shock. Destructive surges are most easily cured on the drawing board. Particular attention should be paid to return or drain lines. Because a line is open to the reservoir or is protected by a low-pressure relief valve, it is not necessarily safe. Sudden changes in rate of flow can cause destructive high-pressure peaks in such lines.

Good workmanship is also essential in piping. Threads must be sharp and tight; welding must be sound; and, above all, the pipes must fit without being strained into position.

The following check list may serve as a guide when reviewing a hydraulic system for potential fire hazards.

1. Loose, vibrating pipes are almost sure to break due to work hardening of the metal. Copper pipe is especially vulnerable to vibration and, if used at all in a danger area, should be only for low pressures (perhaps under 300 psi) and where the piping is protected against vibration.

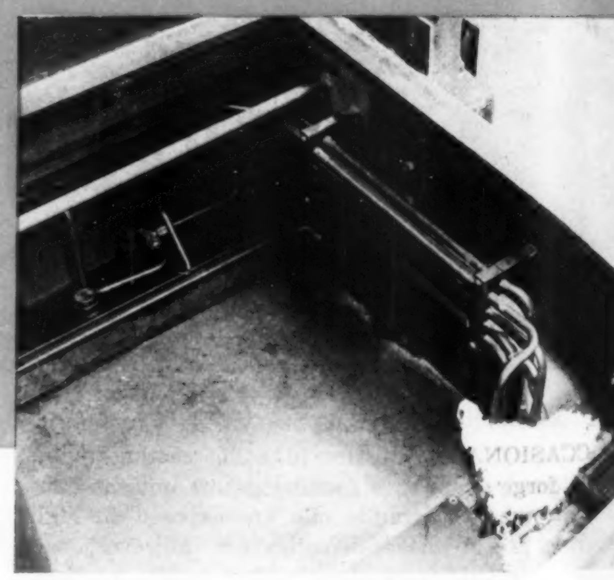
2. Flexible hose should be looked at critically and selected with great care. An alternative for dangerous areas would be telescoping joints, rotary joints or, if the hose is desired only to provide flexibility for adjustment, two or more unions which may be loosened when the adjustment is to be made.

3. Small, fragile piping should not be located where it can be walked on, run over or used as a ladder.

4. Careless piping practices must not be tolerated in places where oil and fire might mix. Sometimes pipes are bent or strained in position either on initial installation or at some later time.

5. Long overhead runs of pipe should be avoided. Any failure would spray a film of oil over wide areas.

Piping under operator's platform is sturdily braced between trench and pump compartment



6. Partitions, when pipes pass through them, should be closed, preferably with asbestos packing.

7. Oil flow must be smooth and free from shock if the machine, equipment, and piping is to continue to function properly. Shock is not essential in the operation of any hydraulic circuit. It is introduced by sudden or jerky movements of the valves or controls. It can usually be eliminated by properly valving the circuit.

The time and expense involved in correcting bad practices is often recovered many times over in the cost of the fluid which has been retained in the system. In times of stress, such as these, fires cannot be tolerated. Let us hope for the ideal fireproof hydraulic fluid, but in the meantime, let us carefully design our machines with the view of incorporating every safety measure recommended to avoid disaster.

Gear Tooth Relieving

When, How and Why

By Harry Pelphrey
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Detroit

UNDER ideal conditions, maximum load-carrying capacity, life expectancy, and quietness of operation are obtained with gears which are accurate as to tooth spacing, concentricity, parallelism, etc., and have true involute form for the entire length of the tooth. Up-to-date gear finishing methods were developed with this end in mind.

But checking the occasionally unsatisfactory unit among many good ones reveals that the cause of trouble is often traceable to heat-treat distortions, slight errors in mounting alignment or shaft deflections under the operating load. Such factors sometimes result in concentrating the contact between mating teeth at one end, *Fig.* 1, obviously an undesirable condition. End bearing is particularly objectionable in helical gears, since the acute angle at the tooth ends already forms a weak point for wear or breakage to start.

Gear tooth relieving, or "crowning" as it is often called, has become a useful expedient to prevent end-bearing. If properly applied, with careful consideration of *all* factors involved, crowning can enhance considerably the service many gears will give.

Gear crowning dates back to the days when accuracy in gears was obtained by grinding. The gear was rocked as the grinding wheel passed between the tooth flanks, making the cut slightly deeper (a few ten thousandths) at the ends of the space, *Fig.* 2. This also thinned the teeth at the ends, preventing end bearing between mating teeth. The form of crown produced is the so-called elliptical crown.

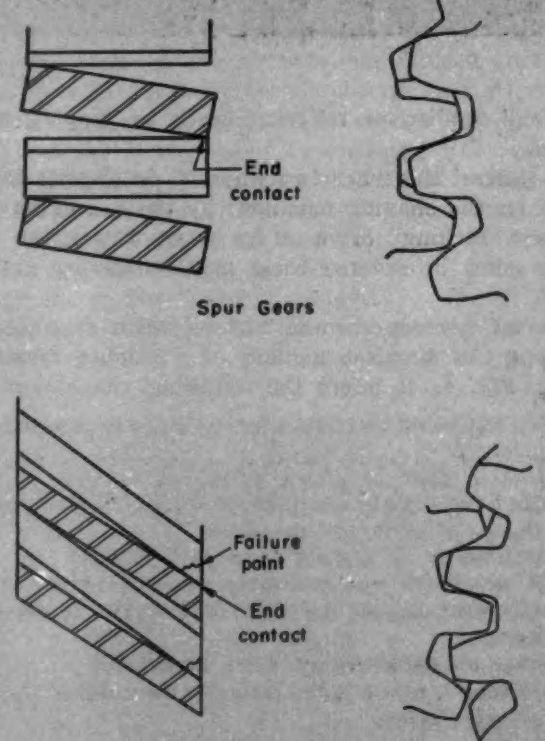


Fig. 1—Slight misalignments between mating gears can cause their teeth to contact at the ends. This condition is particularly to be avoided in helical gears because the thin, acute-angle tooth ends are incipient failure points

Correct Relief Important

The elliptical form of relief still has its place in many applications. But modern gear production machines have made possible various other useful forms of end relief to suit varying conditions. Correct selection of the type of end relief best suited to the individual case is quite simple and insures that any end-bearing problem will be solved with maximum effectiveness and minimum loss of tooth-to-tooth contact. Use of the wrong form, on the other hand, can materially weaken gear teeth and shorten gear life.

Not only the *amount* of relief, but the best *type* and *shape* of the relief and the location of the high point vary with the specific application. *Fig.* 3 illustrates some useful basic relief forms which will be discussed.

How Gear Teeth are Crowned: Because of the varieties of tooth relief required to meet different operating conditions, it has been necessary to develop means of incorporating the desired type and amount into the gear teeth in as simple a manner as possible. Nowadays teeth are relieved usually during the shaving operation. This process is called "crown-shaving" by Michigan Tool Company. Crown-shaving includes *all* methods of gear tooth relieving (including those of *Fig.* 3) employed on Michigan shaving machines regardless of the final tooth form. Similarly, "crown-

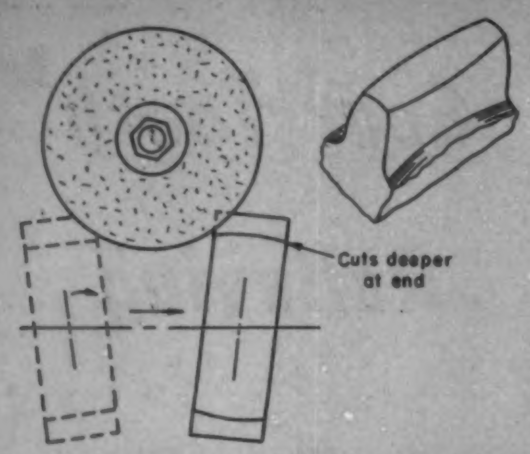


Fig. 2—Above—Early methods to relieve gear tooth ends included rocking the gear during grinding in the plane of the grinding wheel as the wheel passed between the tooth flanks, thus making the cut slightly deeper, and the teeth thinner at the ends. The tooth form produced in this way was the elliptical crown

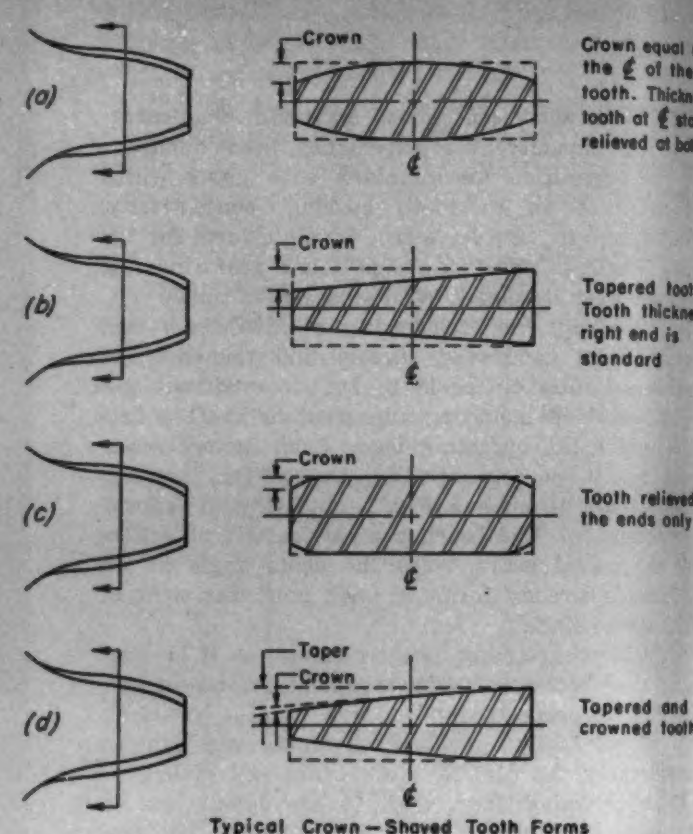


Fig. 3—Right—Various forms of crowns have been developed to suit various manufacturing and operating conditions. Typical ones are shown in views *a* to *d*

lapping" applies to relieving teeth on lapping machines.

In general there are two ways of developing tooth relief on the shaving machine: by the use of an accessory "rocking" drive or by incorporating the desired relief in reverse form in the shaving cutter itself.

Use of reverse-crowned cutters, when feasible, is perhaps the simplest method of obtaining crowned gears, *Fig.* 4. It offers the following advantages:

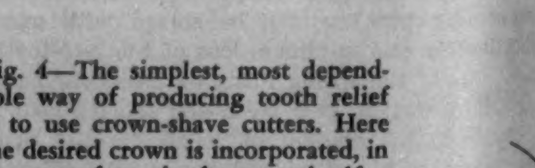
1. No additional cost (even for the cutters) is usually involved
2. Desired form of crown (elliptical, tapered, etc.) can be accurately incorporated in the cutter without chance of variations therefrom
3. Uniformity is assured from part to part
4. A secondary machine setup operation (with its attendant chance for error and scrap) is eliminated
5. Cost of an accessory drive is avoided
6. Method is also most suitable for crowning of close shoulder gears.

Crown-shaving with reverse-crowned cutters in most cases adds no extra time to the operation. Limiting factor in the applicability of the reverse-crowned-cutter method usually is the width of the gear. A good rule of thumb is to use $2\frac{1}{2}$-inch face width as a rough dividing line. Gears above this face width usually should be shaved and end-relieved with regular straight-faced cutters using the transverse reciprocation method of shaving.

ALTERNATE METHOD: The principle of the alternate method—using a separate machine movement to relieve the teeth—is shown in *Fig.* 5, as worked out on Michigan 870 series shaving machines. It is similar in effect to the method used for crowning gears on hobbers or gear grinding machines but has some special advantages.

Fig. 5 shows the machine drive schematically from the front. Slide *A* reciprocates as shown to sweep the work back and forth across the narrow cutter while

Fig. 4—The simplest, most dependable way of producing tooth relief is to use crown-shave cutters. Here the desired crown is incorporated, in reverse form, in the cutter itself



rotating in mesh. The slide is a two-piece assembly pivoted at the point shown. At *B* is a rotatable "cam" with a slot in which freely slides a follower connected to the pivoted work slide. If the cam slot is parallel to the table movement there is no rocking action and gear teeth will be straight and unrelieved. If the slot is set at an angle, however, the work-slide will rock slightly about the pivot pin as it reciprocates, the angular setting of the slot determining the amount of relief which will be produced. The location of the relief—or at least of the high point of the crown along the tooth face—is controlled by the mounting of the work in relation to the pivot point of the work slide. If the gear is central, an elliptical tooth form will be produced. Mounting the gear to one side or the other shifts the high point to one side or the other. Thus the method can be used to produce even the relief shown in *Fig. 3d.*

Effect of Shaving Method: Several factors enter into the determination of whether reverse-crowned cutters or the rocker attachment should be used to crown gears. One of these is the shaving method employed.

Gears may be crown-shaved while shaving by any of the three rotary shaving methods: Underpass, modified underpass, or transverse shaving.

In underpass shaving, the feed of the gear is at right angles to the work axis. This is the fastest known shaving method and gives the longest cutter life. Here crowning is most easily accomplished by a reverse-crowned cutter, the cutter being slightly wider than the gear to be crown-shaved.

In modified underpass shaving, the feed of the gear is diagonal to the cutter and a slightly narrower cutter can be used if desired. The greater the angle of feed, the narrower the cutter can be in relation to gear width. However, the greater the angle, the longer also is the time cycle of the machine per gear. Reverse-crowned cutters may be used to crown-shave by the modified underpass method.

In transverse shaving, the rotating cutter feeds radially into the gear while the gear is reciprocated across the cutter face. This method allows still narrower cutters to be used, but the process is slower than either underpass or modified underpass shaving. It is used mainly for small job-lot gear production, or where gears or splines are extremely wide. Crowning when required on such gears or splines is usually done under this method of shaving with the rocker attachment.

Thus, if high productivity is a major consideration, underpass crown-shaving with reverse-crowned cutters supplies the best answer. If gears are being produced on an odd-lot or job shop basis, the transverse shaving method using a rocker attachment may be employed. Modified underpass shaving lies between these two methods as to both cutter width and productivity.

Selection Affects Cutter Life

However, when specifying the method, it should be remembered that the life of a narrow cutter will usually be proportionately less than that of a wider cutter when used to do the same job. In addition, cutter wear is distributed best with underpass shaving. Therefore, it is often false economy to specify transverse or modified underpass crown-shaving if the job can be done faster with a reverse-crowned cutter by the underpass method.

An exception might be where there is a need to produce small quantities of gears of the same pitch and pressure angle, but with different shapes of crowns. Here each gear with a different crown, if shaved with reverse-crowned cutters, would require its own cutter. In addition, a straight-faced cutter may be required to shave the uncrowned gears which mate with them. The rocker method of course would permit all such gears to be crown-shaved with straight faced cutters. However the variety of crowns obtainable would be more limited, and set-up time would be longer as mentioned previously.

The basic question in this case would be whether enough gears of any one type would be produced

Fig. 5—Another effective way of producing tooth relief is by the use of "rocking" attachments on gear shaving machines. The principle by which these mechanisms work is somewhat similar to the method used on some gear hobbers and grinders

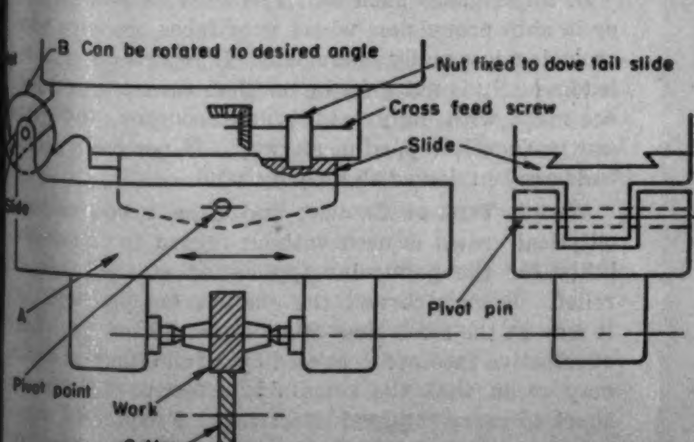
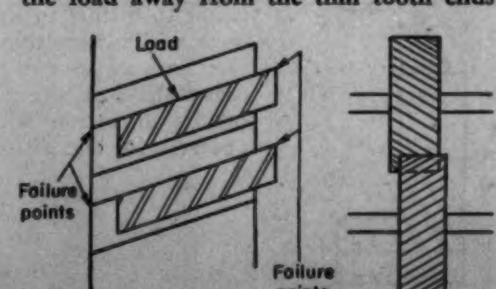


Fig. 6—Below—The need to crown helical gear teeth may sometimes be avoided simply by mounting the gears in a slightly "staggered" position endwise. This keeps the load away from the thin tooth ends



eventually to warrant the initial outlay for the larger number of cutters. One smaller manufacturer of miscellaneous diesel engine gears, for instance, employs individual reverse-crowned cutters for runs of only 25 gears or so, then holds the cutters for repeat runs of the same part. To him, the gear performance obtained outweighs the delay in complete recovery of the cutter cost.

Crown-Lapping: If lapping is part of the production procedure for a gear, the gear may be relieved in the lapping machine. However, this is a slower, less dependable method than relieving in the gear shaver and only the elliptical crown can be effectively produced. Lapping to relieve gear teeth is at most an expedient on very short runs or in making a single, experimental part.

Crown-lapping uses two or more laps set to different angles with the axis of the work. After a number of pieces have been crown-lapped, it is necessary to increase the crossed-axis angle; this is because the laps tend to conform to the shape of the part and would soon fail to produce the desired crown.

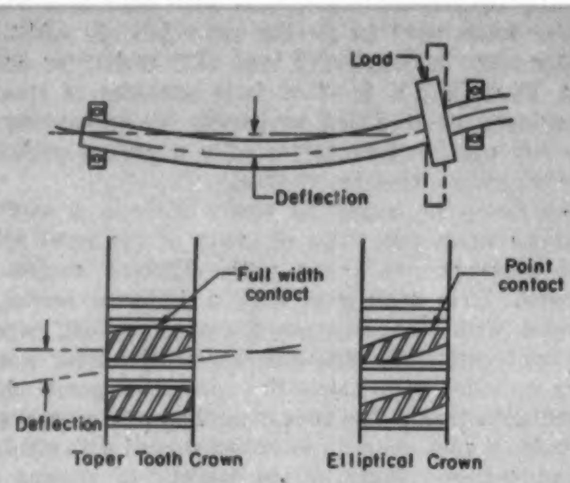


Fig. 7—Above—Different end-bearing conditions call for different types of gear tooth relief. Shown here is a shaft deflection condition which can be compensated for by a combined tapered (left) and elliptical (right) crown. Use of a plain elliptical crown, alone, in this application would tend to weaken the gears

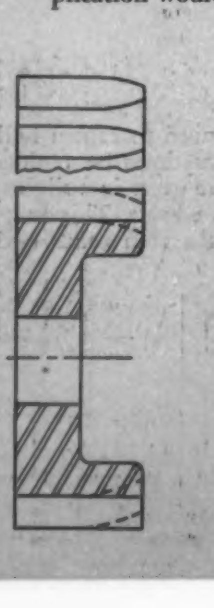


Fig. 8—Left—A gear with a large counterbore at one end is apt to distort so that the teeth will become thinner at one end as shown. Taper crown-shaving the reverse of the distortion will precorrect for the distortion

When to Crown and How Much: It is rarely necessary to relieve the teeth in *both* gears of a pair. Best practice, whenever possible, is to crown-shave only the pinion, which pinion usually does the most work, runs the fastest, and is thus most liable to failure. Where there are three gears in a train, and tooth-relieving is required for both pairs, best practice usually is to crown-shave only the center gear—the amount and type of relief being selected to take care of contact conditions with *both* of the other gears.

An exception is where a long pinion runs with two or more gears. Here it is usually best to crown-shave the gears. If the pinion is crowned the effect is the same, obviously, as if the gears mated with a pinion of slightly incorrect lead.

When lapping gears together in pairs after hardening, both gears should be crowned. Otherwise one may lap a reverse crown into the other.

The amount of relief should depend on specific operating conditions for each pair of gears under consideration. The amount preferably should not exceed the minimum necessary since excessive crowning does have the effect of narrowing the effective gear face width or concentrating the load at a point. Both tend to adversely affect the service life of the gears. Thus, the amount of crown should be just enough to compensate for normal mounting deflection plus normal manufacturing tolerances in shafts and housings, heat treat distortions and errors in the gear tooth lead.

Curing Gear Failures

Nonshaved End Reliefs: Even though there is end loading, the need for crowning may be avoided at times. For example it is sometimes possible to cure a failure of helical gears at their thin acute ends simply by mounting the gears so that the ends of the teeth of one gear extend slightly beyond the other, *Fig.* 6, thus keeping the load off the thin tooth ends. Also, if one of a pair of gears fails in service through end bearing, the one that did not fail can some time be made slightly narrower, to eliminate contact at the extreme ends of the teeth. The increase in life obtained with this expedient is sometimes quite surprising.

In large gears such as those used in powerhouses or in ship propulsion, where gear faces are very wide, crowning is usually inadvisable. Here deflection under load usually is not a major problem since the housings are made with high rigidity and accuracy, and gears are frequently lapped-in anyway. If necessary, tooth ends can be relieved slightly by hand.

Which Type of Crown: Too often, a conventional elliptical crown is used without regard to the desirability for the particular application of that form of relief. It may correct the end-bearing problem, but it may at the same time cause other difficulties. Loss of effective face width caused by a full elliptical crown may mean that the remaining effective face is too short to carry the load effectively. Frequently, when this happens, gear size may have to be increased or the gear otherwise strengthened, when the obvious

solution would have been to use a different form of crown.

However, the errors and deflections which sometimes create the desirability of using some form of tooth relief usually follow a definite pattern in each particular case. The best way to determine the kind (and amount) of crown to be used is to identify the pattern and then crown-shave the minimum relief that will compensate for it.

If the study reveals that an excessive amount of crown-shaving is required to correct a condition, it might be far wiser to correct the inherent condition which results in the misalignment, deflection, etc. Where this procedure is followed, the best and most durable gears will result. There follow a few examples of how some of the different patterns may be compensated for in design.

Modifications for Long Shafts

Suppose a gear is mounted at one end of a long shaft between two improperly aligned bearings as in *Fig.* 7. Here end bearing introduced by misalignment itself may not be a major problem because the distance between supports reduces the angle. But the long shaft may also deflect in the center under the operating load, thereby causing the mating teeth to contact at the ends nearest the support bearing. In this case, a conventional elliptical crown would have to be quite large in order to avoid the end bearing and would cut down the effective tooth width considerably. If the crown is modified by placing the high point away from the shaft bearing, however, close to full-width tooth contact may be secured.

A tapered tooth of this type may be useful also in eliminating a tendency for transmission gears to jump out of mesh. It gives the tooth load a slight angle in the direction that holds the gears in mesh. A tapered tooth form of crown is also useful in correcting a common form of heat treat distortion. *Fig.* 8 shows a gear with a large counterbore in one end. Heat treatment may distort such a gear so that the teeth become slightly thicker at the solid end. Crown-shaving a tapered relief will pre-correct for the distortion and leave straight teeth *after* heat treating. If it is desired to produce an end relief in the finished gear, the crown-shave cutter can be designed to provide the combination of taper plus added end relief. The taper disappears in heat treatment but the gear is left with the desired tooth relief. On jobs of this kind, it is usually best to use reverse-crowned cutters.

In some transmissions, gear shifting may be facilitated by using reverse-crowned cutters and the underpass shaving method to relieve teeth at *one end only* without resorting to the extra operation of pointing the teeth.

Sometimes a slight relief at the tooth ends only, *Fig.* 3*c*, reduces gear noise; thus the desired effect is obtained with minimum loss of effective face width. This may be done by a second shaving operation or by employing two cutters simultaneously on a special machine. Thus, actually there could be almost as many *forms* of crown-shaved gear teeth as there are gear applications, particularly when the *amount* of relief required is taken into consideration.

Finally, when it has been determined that some form of crown is desirable, it is wise to work with the shaving cutter manufacturer to be sure that the cutter will produce the desired crown in practice. This is particularly true when a *modified* underpass (using a diagonal feed) is used.

It should be remembered, however, that if there were no deflections, uncrowned gears which mate and operate correctly normally would be better gears with a longer life expectancy than those which have been crowned. While gear shaving has increased the quietness and life of gears, particularly at higher speeds, it indirectly also has made more important the maintenance of *maximum* effective tooth to tooth contact. This is true wherever the high, uniform load capacity of shaved gears has been taken advantage of by reducing gear size in proportion to load carried.

The load carrying capacity of a shaved gear, when correctly aligned in service, is equal to the capacity of a considerably larger unshaved gear, mainly due to the excellent load distribution. If distortion, deflection, misalignment, etc., cancel out this advantage by causing a concentration of load at one point of a tooth, the chance of failure or rapid wear would be greater even than with a somewhat larger but accurately mating gear. Often it has been possible to avoid the necessity of gear tooth crowning or to reduce the amount of crown necessary under such conditions by working out with the gear producer minor changes in the design and processing of gear assemblies, resulting in overall improvement of the unit.

Casting Ductile Iron Pump Casings

USE of nodular iron for heavy pump casings has been initiated by the DeLaval Steam Turbine Co., Trenton, New Jersey. Satisfactory hydrostatic tests on these units show only slight deflection at 750 psi and no leakage at 1500 psi. The case and cover illustrated, cast by the Farrel-Birmingham foundry at Derby, Conn., have a combined weight of 8314

pounds and the substitution of nodular iron for steel in a unit of this size represents an appreciable saving in cost. Crux of the casting process, which requires the most meticulous control, is the introduction of the small but effective amount of magnesium which converts the graphite to spheroidal form.

Mechanism Design

Analytical solution and punched-card calculating machines offer fast method of constructing numerical tables of displacement, velocity and acceleration for a quick-return mechanism

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ANALYTICAL approach to the study of mechanisms has never been popular. Probable reasons include: (1) analytical solutions are not available in the literature; (2) there is considerable work in carrying out a numerical analysis from such a solution; and (3) the required accuracy may not exceed that which can be obtained by conventional graphical means.

Recent deevlopments in computing devices and their greater availability now make it possible to run off large numbers of calculations in a reasonable time. This means that many analytical solutions, or at least a number of steps in the solutions, can be mass produced and tabulated. The work of doing a numerical analysis can then be reduced, often to less than that by conventional graphical methods. When a high degree of accuracy is required, the analytical approach has many advantages and may offer the only method of solution.

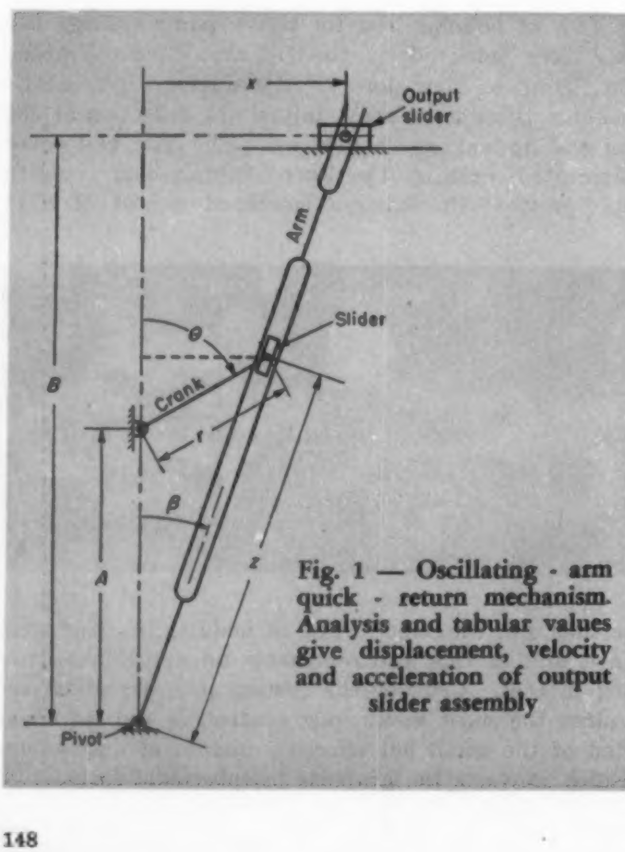
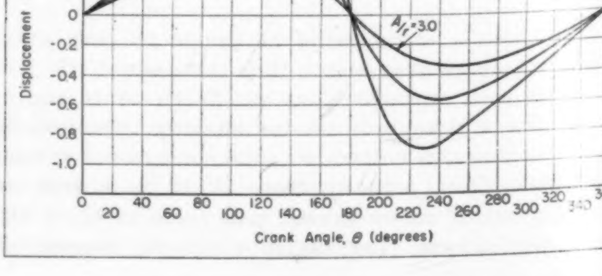


Fig. 1 — Oscillating - arm quick - return mechanism. Analysis and tabular values give displacement, velocity and acceleration of output slider assembly

Using as an example the well-known oscillating-arm quick-return motion illustrated in *Fig.* 1, this article shows how the equations of motion are derived, and how punched-card calculating machines can be employed to determine tabular values. Complete tables of displacement, velocity and acceleration are given, covering the practical range of proportions of the mechanism being studied.

DERIVATION OF EQUATIONS: As shown in *Fig.* 1, the mechanism consists of a crank of radius r, which is assumed to be turning at constant angular velocity and which is described by the angle θ, such that

Fig. 2—Displacement of output slider for three different mechanism proportions



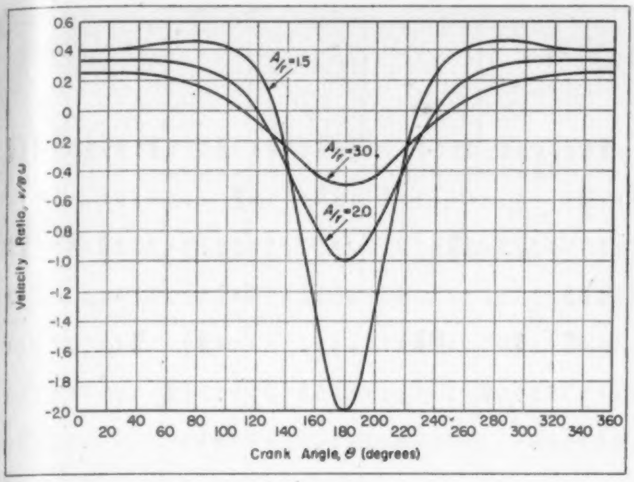


Fig. 3—Velocity of output slider for the same mechanism proportions as in Fig. 2

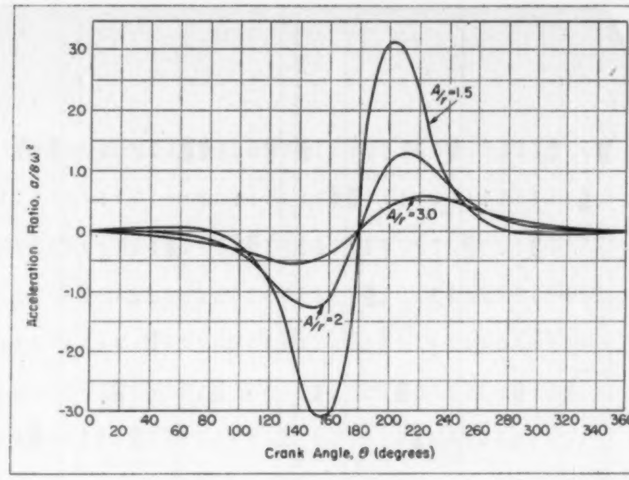


Fig. 4—Acceleration of output slider for the mechanisms in Figs. 2 and 3

$\theta = \omega t$. The crank drives an arm, pivoted as shown, through a slider. This arm, in turn, drives the output slider, which is guided so that it will move in a straight line. In the analysis, β represents the angle the long arm makes with the centerline of the mechanism, A is the distance between the crank center and pivot, B is the perpendicular distance between the pivot and the plane in which the output slider moves, and x is the displacement of this slider from the centerline of the mechanism.

Referring to *Fig.* 1, it is evident that the relation between the crank angle θ and the angle β can be expressed in these terms:

$$z \sin \beta = r \sin \theta \qquad (1)$$

$$z \cos \beta = A + r \cos \theta \qquad (2)$$

If Equation 1 is divided by Equation 2,

$$\tan \beta = \frac{r \sin \theta}{A + r \cos \theta} \qquad (3)$$

To find the displacement of the output slider, x,

$$\tan \beta = \frac{x}{B} \qquad (4)$$

from which

$$x = B \tan \beta = \frac{Br \sin \theta}{A + r \cos \theta} = \frac{B \sin \theta}{\frac{A}{r} + \cos \theta} \qquad (5)$$

Table 1—Values of Displacement Ratios (x/B)

	Crank Angle θ (degrees)												
A/r	0	15	30	45	60	75	90	105	120	135	150	165	180
8.0	0.0000	0.0288	0.0564	0.0812	0.1019	0.1169	0.1250	0.1248	0.1155	0.0970	0.0701	0.0368	0.0000
7.5	0.0000	0.0306	0.0598	0.0861	0.1082	0.1245	0.1333	0.1334	0.1237	0.1041	0.0754	0.0396	0.0000
7.0	0.0000	0.0325	0.0635	0.0917	0.1154	0.1331	0.1428	0.1433	0.1332	0.1124	0.0815	0.0429	0.0000
6.5	0.0000	0.0346	0.0678	0.0981	0.1237	0.1429	0.1538	0.1548	0.1443	0.1221	0.0887	0.0468	0.0000
6.0	0.0000	0.0371	0.0728	0.1054	0.1332	0.1543	0.1666	0.1682	0.1575	0.1336	0.0974	0.0514	0.0000
5.5	0.0000	0.0400	0.0785	0.1139	0.1443	0.1677	0.1818	0.1843	0.1732	0.1475	0.1079	0.0571	0.0000
5.0	0.0000	0.0434	0.0852	0.1239	0.1574	0.1837	0.2000	0.2037	0.1925	0.1647	0.1209	0.0642	0.0000
4.0	0.0000	0.0473	0.0932	0.1358	0.1732	0.2030	0.2222	0.2277	0.2165	0.1864	0.1376	0.0732	0.0000
4.5	0.0000	0.0521	0.1027	0.1502	0.1924	0.2268	0.2500	0.2582	0.2474	0.2147	0.1595	0.0853	0.0000
3.5	0.0000	0.0579	0.1145	0.1681	0.2165	0.2570	0.2857	0.2980	0.2887	0.2532	0.1898	0.1021	0.0000
3.0	0.0000	0.0653	0.1293	0.1907	0.2474	0.2964	0.3333	0.3524	0.3464	0.3084	0.2343	0.1272	0.0000
2.9	0.0000	0.0669	0.1327	0.1960	0.2547	0.3058	0.3448	0.3657	0.3608	0.3225	0.2458	0.1338	0.0000
2.8	0.0000	0.0687	0.1364	0.2016	0.2624	0.3158	0.3571	0.3801	0.3765	0.3379	0.2585	0.1411	0.0000
2.7	0.0000	0.0706	0.1402	0.2075	0.2706	0.3264	0.3703	0.3957	0.3937	0.3548	0.2726	0.1493	0.0000
2.6	0.0000	0.0726	0.1443	0.2138	0.2794	0.3379	0.3846	0.4126	0.4124	0.3736	0.2884	0.1584	0.0000
2.5	0.0000	0.0747	0.1485	0.2206	0.2887	0.3501	0.4000	0.4310	0.4330	0.3944	0.3060	0.1687	0.0000
2.4	0.0000	0.0769	0.1531	0.2276	0.2986	0.3633	0.4166	0.4511	0.4558	0.4177	0.3260	0.1805	0.0000
2.3	0.0000	0.0792	0.1579	0.2351	0.3093	0.3775	0.4347	0.4732	0.4811	0.4439	0.3487	0.1940	0.0000
2.2	0.0000	0.0817	0.1631	0.2432	0.3207	0.3928	0.4545	0.4976	0.5094	0.4737	0.3748	0.2097	0.0000
2.1	0.0000	0.0844	0.1686	0.2519	0.3331	0.4095	0.4761	0.5246	0.5413	0.5077	0.4052	0.2282	0.0000
2.0	0.0000	0.0873	0.1744	0.2612	0.3464	0.4276	0.5000	0.5548	0.5774	0.5469	0.4409	0.2503	0.0000
1.9	0.0000	0.0903	0.1808	0.2712	0.3608	0.4474	0.5263	0.5886	0.6186	0.5928	0.4836	0.2771	0.0000
1.8	0.0000	0.0936	0.1875	0.2820	0.3765	0.4691	0.5556	0.6267	0.6662	0.6470	0.5353	0.3103	0.0000
1.7	0.0000	0.0971	0.1948	0.2937	0.3936	0.4931	0.5882	0.6702	0.7217	0.7122	0.5995	0.3526	0.0000
1.6	0.0000	0.1008	0.2027	0.3065	0.4124	0.5196	0.6250	0.7202	0.7873	0.7919	0.6812	0.4082	0.0000
1.5	0.0000	0.1050	0.2113	0.3204	0.4330	0.5492	0.6666	0.7782	0.8660	0.8918	0.7887	0.4846	0.0000
1.4	0.0000	0.1094	0.2206	0.3356	0.4557	0.5823	0.7143	0.8464	0.9633	1.0206	0.9364	0.5962	0.0000
1.3	0.0000	0.1142	0.2308	0.3523	0.4811	0.6196	0.7692	0.9277	1.0825	1.1926	1.1521	0.7747	0.0000
1.2	0.0000	0.1195	0.2420	0.3708	0.5094	0.6621	0.8333	1.0263	1.2372	1.4346	1.4971	1.1057	0.0000
1.1	0.0000	0.1253	0.2543	0.3913	0.5412	0.7108	0.9091	1.1483	1.4434	1.7998	2.1370	1.9304	0.0000

* All values are positive up to $\theta = 180°$. Values are symmetricalabout 180°, but are negative between 180 and 360°. See *Fig.* 2.

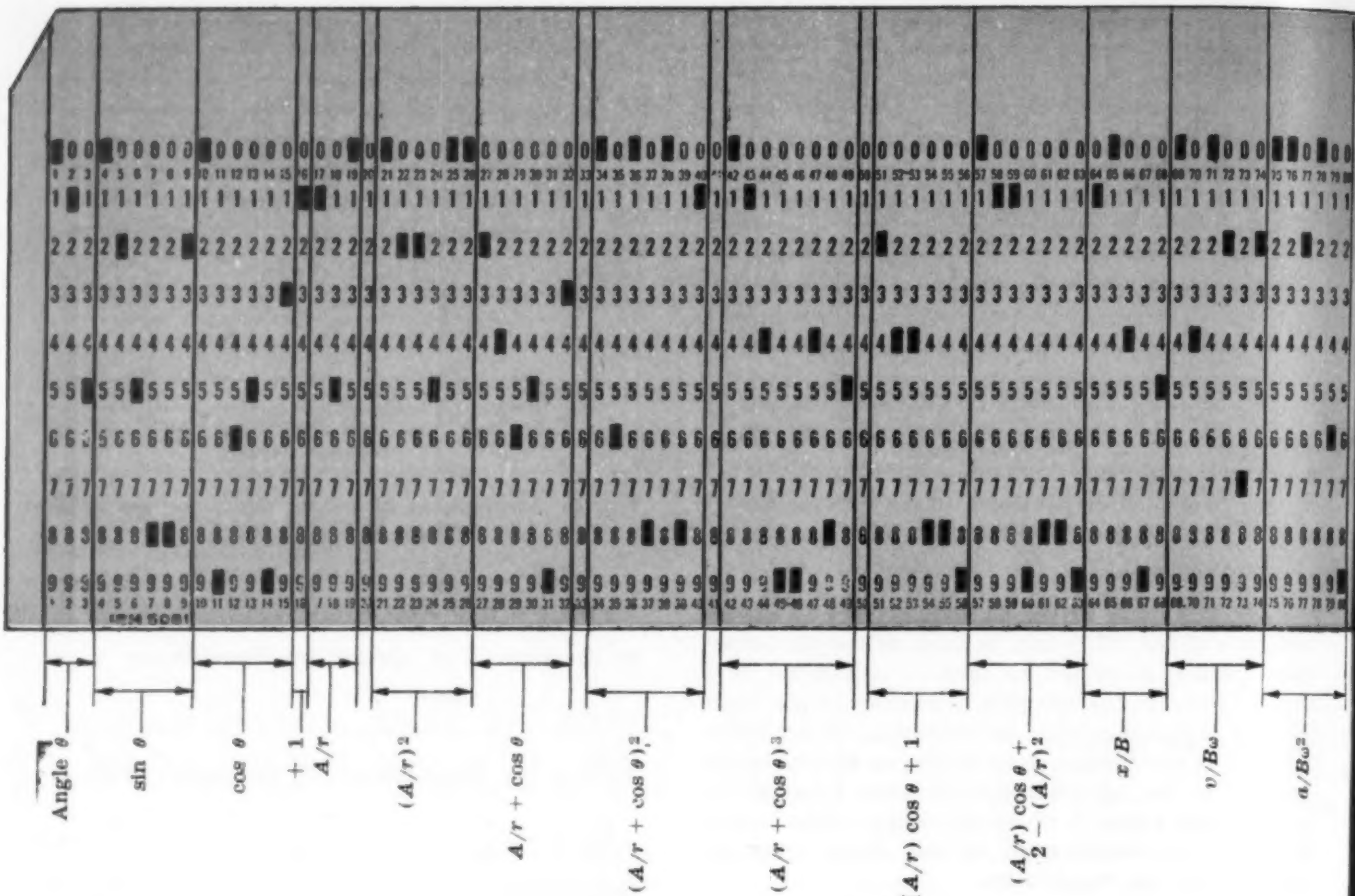


Fig. 5—Typical punched card used in calculating tabular values. This card is for the 15-degree position (columns 1 to 3), for which $\sin\theta$ is 0.25882 (columns 4 to 9) and $\cos\theta$ is 0.96593 (columns 10 to 15). The particular A/r ratio here is 1.50 (columns 17 to 19). The three answers are found in columns 64 to 80, from which they can be printed with the aid of a tabulator. The printed tape can be rearranged as desired in convenient form as a table

Table 2—Values of Velocity Ratios $(v/B\omega)$

	Crank Angle θ (degrees)												
A/r	0	15	30	45	60	75	90	105	120	135	150	165	180
8.0	0.1111	0.1065	0.1008	0.0878	0.0692	0.0450	0.0156	−0.0179	−0.0533	−0.0876	−0.1165	−0.1360	−0.1429
7.5	0.1176	0.1150	0.1070	0.0936	0.0742	0.0488	0.0178	−0.0179	−0.0561	−0.0933	−0.1249	−0.1463	−0.1538
7.0	0.1250	0.1223	0.1141	0.1001	0.0800	0.0534	0.0204	−0.0179	−0.0592	−0.0997	−0.1345	−0.1562	−0.1667
6.5	0.1333	0.1306	0.1222	0.1077	0.0867	0.0587	0.0236	−0.0175	−0.0625	−0.1072	−0.1458	−0.1724	−0.1818
6.0	0.1428	0.1400	0.1314	0.1165	0.0946	0.0652	0.0278	−0.0168	−0.0661	−0.1157	−0.1592	−0.1892	−0.2000
5.5	0.1538	0.1510	0.1422	0.1269	0.1042	0.0731	0.0330	−0.0154	−0.0700	−0.1258	−0.1752	−0.2098	−0.2222
5.0	0.1666	0.1638	0.1549	0.1392	0.1157	0.0829	0.0400	−0.0131	−0.0741	−0.1376	−0.1949	−0.2353	−0.2500
4.5	0.1818	0.1790	0.1701	0.1542	0.1300	0.0956	0.0493	−0.0092	−0.0781	−0.1517	−0.2194	−0.2680	−0.2857
4.0	0.2000	0.1972	0.1885	0.1728	0.1481	0.1123	0.0625	−0.0025	−0.0816	−0.1686	−0.2500	−0.3111	−0.3333
3.5	0.2222	0.2196	0.2115	0.1963	0.1719	0.1349	0.0816	0.0000	−0.0833	−0.1891	−0.2928	−0.3707	−0.4000
3.0	0.2500	0.2478	0.2407	0.2271	0.2041	0.1673	0.1111	0.0297	−0.0800	−0.2133	−0.3509	−0.4586	−0.5000
2.9	0.2564	0.2543	0.2476	0.2344	0.2119	0.1754	0.1189	0.0358	−0.0781	−0.2185	−0.3654	−0.4815	−0.5263
2.8	0.2631	0.2612	0.2548	0.2423	0.2204	0.1843	0.1275	0.0426	−0.0756	−0.2237	−0.3810	−0.5067	−0.5556
2.7	0.2703	0.2684	0.2625	0.2506	0.2295	0.1940	0.1371	0.0505	−0.0723	−0.2289	−0.3970	−0.5347	−0.5882
2.6	0.2777	0.2761	0.2706	0.2595	0.2393	0.2047	0.1479	0.0597	−0.0680	−0.2340	−0.4163	−0.5660	−0.6250
2.5	0.2857	0.2842	0.2793	0.2691	0.2500	0.2164	0.1600	0.0703	−0.0625	−0.2388	−0.4364	−0.6012	−0.6666
2.4	0.2941	0.2929	0.2886	0.2794	0.2616	0.2293	0.1736	0.0826	−0.0554	−0.2432	−0.4583	−0.6410	−0.7143
2.3	0.3030	0.3020	0.2985	0.2904	0.2742	0.2436	0.1890	0.0971	−0.0463	−0.2469	−0.4824	−0.6864	−0.7692
2.2	0.3125	0.3117	0.3090	0.3024	0.2881	0.2596	0.2066	0.1143	−0.0346	−0.2493	−0.5087	−0.7387	−0.8333
2.1	0.3225	0.3222	0.3204	0.3154	0.3032	0.2774	0.2267	0.1347	−0.0195	−0.2490	−0.5376	−0.7996	−0.9091
2.0	0.3333	0.3333	0.3326	0.3294	0.3200	0.2974	0.2500	0.1591	0.0000	−0.2478	−0.5693	−0.8714	−1.0000
1.9	0.3448	0.3452	0.3457	0.3448	0.3385	0.3200	0.2770	0.1887	0.0255	−0.2414	−0.6037	−0.9573	−1.1111
1.8	0.3571	0.3580	0.3600	0.3616	0.3591	0.3458	0.3086	0.2249	0.0592	−0.2284	−0.6407	−1.0618	−1.2500
1.7	0.3704	0.3717	0.3754	0.3800	0.3822	0.3753	0.3460	0.2696	0.1042	−0.2050	−0.6790	−1.1916	−1.4286
1.6	0.3846	0.3866	0.3923	0.4004	0.4082	0.4093	0.3906	0.3257	0.1653	−0.1648	−0.7159	−1.3567	−1.6667
1.5	0.4000	0.4027	0.4107	0.4230	0.4375	0.4487	0.4444	0.3971	0.2500	−0.0965	−0.7440	−1.5738	−2.0000
1.4	0.4166	0.4202	0.4308	0.4482	0.4709	0.4951	0.5102	0.4896	0.3704	0.0209	−0.7451	−1.8698	−2.5000
1.3	0.4348	0.4393	0.4531	0.4764	0.5092	0.5500	0.5917	0.6121	0.5469	0.2297	−0.6682	−2.2912	−3.3333
1.2	0.4545	0.4602	0.4777	0.5082	0.5536	0.6158	0.6944	0.7783	0.8163	0.6234	−0.3517	−2.9045	−5.0000
1.1	0.4762	0.4832	0.5052	0.5444	0.6054	0.6957	0.8264	0.2037	0.1925	1.4393	0.8652	−3.4791	−10.0000

* Values are positive unless otherwise indicated, and are symmetrical, with signs unchanged, about 180°. See *Fig. 3*.

Substituting $\theta = \omega t$, Equation 5 becomes

$$x = \frac{B \sin \omega t}{\frac{A}{r} + \cos \omega t} \qquad (6)$$

To find the velocity of the output slider, the derivative of Equation 6 with respect to time can be taken

$$v = \frac{dx}{dt} = \frac{B\omega \left[\frac{A}{r} \cos \omega t + 1 \right]}{\left[\frac{A}{r} + \cos \omega t \right]^2} \qquad (7)$$

The acceleration of the output slider will be given by the second derivative of x, or

$$a = \frac{d^2x}{dt^2} = \frac{B\omega^2 \sin \omega t \left[\frac{A}{r} \cos \omega t + 2 - \left(\frac{A}{r} \right)^2 \right]}{\left[\frac{A}{r} + \cos \omega t \right]^3} \qquad (8)$$

In order to increase the scope of application of the results and to simplify calculations, these equations can be reduced to a more convenient form by writing as follows:

$$\frac{x}{B} = \frac{\sin \theta}{\frac{A}{r} + \cos \theta} \qquad (9)$$

$$\frac{v}{B\omega} = \frac{\frac{A}{r} \cos \theta + 1}{\left[\frac{A}{r} + \cos \theta \right]^2} \qquad (10)$$

$$\frac{a}{B\omega^2} = \frac{\sin \theta \left[\frac{A}{r} \cos \theta + 2 - \left(\frac{A}{r} \right)^2 \right]}{\left[\frac{A}{r} + \cos \theta \right]^3} \qquad (11)$$

It can be seen that the values of the right-hand side of Equations 9, 10, and 11 depend only on θ and the ratio A/r. Calculated results then can be easily tabulated, since only a two-dimensional table is needed. Furthermore, the system is symmetrical, so that if the results for $0 < \theta < 180$ are obtained, the results for $180 < \theta < 360$ will be symmetrical about the 180-degree position.

Use of Tabulated Values: Table 1 lists values of x/B for 15-degree crank positions from 0 to 180 degrees inclusive, for values of A/r ranging from 1.1 to 8.0. Table 2 gives the corresponding values of $v/B\omega$ and Table 3 gives $a/B\omega^2$. Since the mechanism is symmetrical, the values of x/B are symmetrical about 180 degrees, the values above 180 degrees having a sign opposite those below 180 degrees, as shown by the example in Table 4. The values of $v/B\omega$ will be symmetrical about 180 degrees, with signs identical for corresponding symmetrical positions. The values of $a/B\omega^2$ are likewise symmetrical about 180 degrees, except here again the signs below 180 degrees are opposite those above 180 degrees.

The value of v is the product of the velocity ratio and $B\omega$. The angular velocity is $\omega = 2\pi N$ radians per minute, where N = revolutions per minute of crank r. Therefore $v = B\omega = 2\pi NB$ feet per minute.

Acceleration a is the product of the acceleration ratio and $B\omega^2$, angular velocity ω being the same as in the foregoing; thus $a = B\omega^2 = B\ (2\pi N)^2$ feet per minute per minute $= \beta(2\pi N)^2/60^2 = 0.01097$

Table 3—Values of Acceleration Ratios $(a/B\omega^2)$

	Crank Angle θ (degrees)												
A/r	0	15	30	45	60	75	90	105	120	135	150	165	180
8.0	0.0000	−0.0195	−0.0395	−0.0603	−0.0818	−0.1027	−0.1210	−0.1334	−0.1355	−0.1233	−0.0949	−0.0519	0.0000
7.5	0.0000	−0.0201	−0.0407	−0.0626	−0.0854	−0.1082	−0.1286	−0.1430	−0.1464	−0.1343	−0.1040	−0.0571	0.0000
7.0	0.0000	−0.0206	−0.0421	−0.0650	−0.0893	−0.1141	−0.1370	−0.1539	−0.1593	−0.1474	−0.1150	−0.0633	0.0000
6.5	0.0000	−0.0211	−0.0433	−0.0673	−0.0934	−0.1207	−0.1466	−0.1666	−0.1744	−0.1631	−0.1283	−0.0711	0.0000
6.0	0.0000	−0.0216	−0.0445	−0.0697	−0.0978	−0.1278	−0.1574	−0.1815	−0.1926	−0.1824	−0.1448	−0.0806	0.0000
5.5	0.0000	−0.0220	−0.0455	−0.0720	−0.1022	−0.1358	−0.1698	−0.1991	−0.2148	−0.2064	−0.1659	−0.0931	0.0000
5.0	0.0000	−0.0221	−0.0462	−0.0740	−0.1067	−0.1442	−0.1840	−0.2202	−0.2423	−0.2372	−0.1934	−0.1097	0.0000
4.5	0.0000	−0.0220	−0.0465	−0.0755	−0.1109	−0.1531	−0.2003	−0.2458	−0.2774	−0.2777	−0.2308	−0.1325	0.0000
4.0	0.0000	−0.0214	−0.0458	−0.0757	−0.1140	−0.1621	−0.2187	−0.2774	−0.3232	−0.3333	−0.2837	−0.1655	0.0000
3.5	0.0000	−0.0200	−0.0433	−0.0738	−0.1150	−0.1700	−0.2391	−0.3165	−0.3849	−0.4130	−0.3634	−0.2168	0.0000
3.0	0.0000	−0.0170	−0.0381	−0.0677	−0.1111	−0.1737	−0.2593	−0.3647	−0.4711	−0.5351	−0.4938	−0.3044	0.0000
2.9	0.0000	−0.0162	−0.0365	−0.0657	−0.1093	−0.1734	−0.2628	−0.3754	−0.4924	−0.5673	−0.5301	−0.3295	0.0000
2.8	0.0000	−0.0152	−0.0346	−0.0633	−0.1070	−0.1727	−0.2660	−0.3864	−0.5153	−0.6032	−0.5713	−0.3584	0.0000
2.7	0.0000	−0.0141	−0.0326	−0.0606	−0.1041	−0.1712	−0.2687	−0.3976	−0.5400	−0.6432	−0.6183	−0.3920	0.0000
2.6	0.0000	−0.0128	−0.0301	−0.0571	−0.1006	−0.1690	−0.2706	−0.4090	−0.5667	−0.6879	−0.6725	−0.4313	0.0000
2.5	0.0000	−0.0114	−0.0274	−0.0532	−0.0962	−0.1657	−0.2720	−0.4202	−0.5954	−0.7383	−0.7353	−0.4778	0.0000
2.4	0.0000	−0.0098	−0.0241	−0.0486	−0.0909	−0.1614	−0.2720	−0.4311	−0.6263	−0.7954	−0.8088	−0.5334	0.0000
2.3	0.0000	−0.0079	−0.0205	−0.0433	−0.0845	−0.1554	−0.2704	−0.4413	−0.6593	−0.8602	−0.8957	−0.6008	0.0000
2.2	0.0000	−0.0058	−0.0162	−0.0370	−0.0765	−0.1476	−0.2667	−0.4502	−0.6945	−0.9342	−0.9995	−0.6837	0.0000
2.1	0.0000	−0.0034	−0.0113	−0.0296	−0.0670	−0.1374	−0.2602	−0.4571	−0.7316	−1.0191	−1.1253	−0.7876	0.0000
2.0	0.0000	−0.0007	−0.0057	−0.0209	−0.0555	−0.1242	−0.2500	−0.4607	−0.7698	−1.1171	−1.2797	−0.9203	0.0000
1.9	0.0000	0.0025	0.0008	−0.0106	−0.0413	−0.1074	−0.2348	−0.4593	−0.8080	−1.2303	−1.4725	−1.0942	0.0000
1.8	0.0000	0.0061	0.0084	0.0015	−0.0242	−0.0857	−0.2126	−0.4501	−0.8436	−1.3612	−1.7177	−1.3286	0.0000
1.7	0.0000	0.0108	0.0172	0.0158	−0.0033	−0.0579	−0.1811	−0.4292	−0.8720	−1.5113	−2.0364	−1.6568	0.0000
1.6	0.0000	0.0151	0.0275	0.0329	0.0224	−0.0219	−0.1368	−0.3900	−0.8849	−1.6801	−2.4604	−2.1377	0.0000
1.5	0.0000	0.0207	0.0396	0.0533	0.0542	0.0246	−0.0741	−0.3224	−0.8660	−1.8593	−3.0398	−2.8804	0.0000
1.4	0.0000	0.0272	0.0539	0.0778	0.0934	0.0851	0.0145	−0.2095	−0.7840	−2.0193	−3.8506	−4.1530	0.0000
1.3	0.0000	0.0348	0.0706	0.1075	0.1426	0.1648	0.1411	−0.0226	−0.5751	−2.0671	−4.9916	−6.5654	0.0000
1.2	0.0000	0.0437	0.0907	0.1436	0.2044	0.2709	0.3241	0.2890	−0.1010	−1.7039	−6.4342	−12.0951	0.0000
1.1	0.0000	0.0544	0.1147	0.1878	0.2833	0.4137	0.5935	0.8200	0.9622	0.1418	−6.3523	−29.3875	0.0000

* Values are positive unless otherwise indicated, and are symmetrical about 180° but with signs changed. See *Fig. 4*.

BN^2 feet per second per second. Values shown in TABLE 4 have been calculated for $A = 15$ inches, $r = 10$ inches, and $B = 30$ inches. This skeleton table shows the manner in which the signs change, and can be used to check the units.

Figs. 2, 3 and 4 show plots of the displacement, velocity and acceleration ratios for three values of A/r. These curves have been plotted from data in TABLES 1, 2, and 3. The velocity curve is the slope of the displacement curve. From the curves shown in *Fig.* 2, it is evident that the slope is maximum at a value of $\theta = 180$ degrees as shown by *Fig.* 4.

CONSTRUCTION OF TABLES: The tables were made using the facilities of the computing center at the University of Minnesota, Institute of Technology. The IBM calculating punch, available as part of the computing center facilities, offers an easy method of carrying out such calculations. TABLES 1, 2 and 3 were calculated by this method, using four-place sine and cosine tables. All results have been tabulated to four decimal places.

Construction of such tables is easy in principle. The main time-consuming element in this particular problem is in setting up the program to be followed and in wiring the boards. The general procedure depends in part on the availability of the machines and other factors. Such problems can perhaps best be carried out in a series of simple calculations where the results are punched on the cards and reused in later calculations. The degree to which this is done depnds on the complexity of the problem. In this example all information, together with intermediate calculations, was carried on one deck of cards; however, it did require the use of most of the card's eighty-column capacity. *Fig.* 5 shows a typical card and indicates the type of information on each card.

Table 4—Displacement, Velocity and Acceleration for a Particular Mechanism

($A = 15$ inches, $r = 10$ inches, $A/r = 1.5$, $B = 30$ inches, $N = 120$ rpm, $\omega = 754$ radians/min)

θ	$\frac{x}{B}$	x (inches)	$\frac{v}{B\omega}$	v (ft/min)	$\frac{a}{B\omega^2}$	a (ft/sec²)
0	0	0	0.4000	754.0	0	0
30	0.2113	0.63390	0.4107	774.17	0.0396	15.636
60	0.4330	1.29900	0.4375	824.69	0.0542	21.401
90	0.6666	1.99980	0.4444	837.69	−0.0741	−29.258
120	0.8660	2.59800	0.2500	471.25	−0.8660	−341.94
150	0.7887	2.36610	−0.7440	−1402.44	−3.0398	−1200.26
180	0	0	−2.0000	−3770.00	0	0
210	−0.7887	−2.36610	−0.7440	−1402.44	3.0398	1200.26
240	−0.8660	−2.59800	0.2500	471.25	0.8660	341.94
270	−0.6666	−1.99980	0.4444	837.69	0.0741	29.258
300	−0.4330	−1.29900	0.4375	824.69	−0.0542	−21.401
330	−0.2113	−0.63390	0.4107	774.17	−0.0396	−15.636
360	0	0	0.4000	754.0	0	0

There are as many cards as there are separate values of θ and A/r.

Initially, a deck of cards for the variable A/r was made up. As many decks, having all values of A/r, were made up as there were values of θ to be covered. Since this problem was symmetrical, only values of θ between 0 and 180 degrees needed to be considered in this case.

Since 15-degree intervals of θ were selected, thirteen complete decks having all values of A/r were made up, each of which represented a particular value of θ. The calculations of the various quantities can either be carried out by using a complex board and a few steps or a simple board and several steps. When the values are all calculated, they can be printed by use of a tabulator. These values can then be rearranged in a convenient form for use such as the tables included with this article.

New Turbosupercharger Outperforms Predecessors

A NEW turbosupercharger—the CH9—makes possible power and economy performance exceeding that of any large powerplants flying today. Made by the General Electric Co. and rigorously tested on the Pratt & Whitney R-4360-C engine, the new turbosupercharger utilizes a power cycle that simplifies the engine, at the same time adding more power. It eliminates the conventional geared supercharger, or impeller, and permits operation without clutches, gearings, or fluid disks. There are no mechanical connections between engine and turbo.

The CH9 turbo handles up to 350 pounds of air per minute, compressing it to a pressure of 50 inches of mercury, absolute. With accessories, the unit weighs 300 pounds. Engineering results from the actual test stand installation of the combined powerplant show 32 per cent more power in take-off and 20 per cent lower fuel consumption than with the present R-4360 engine and its turbo. Average true airspeed can be increased substantially, depending on flight distance, due to greater power permitting flights at altitudes where turbulence and air drag are reduced. Along with increased speed and power, specific fuel consumption of 0.36-pound per bhp per hour can be realized. Cabin air conditioning can be provided by the CH9 at altitudes up to 30,000 feet.

Redesign to Simplify Tooling

By Arthur F. Murray
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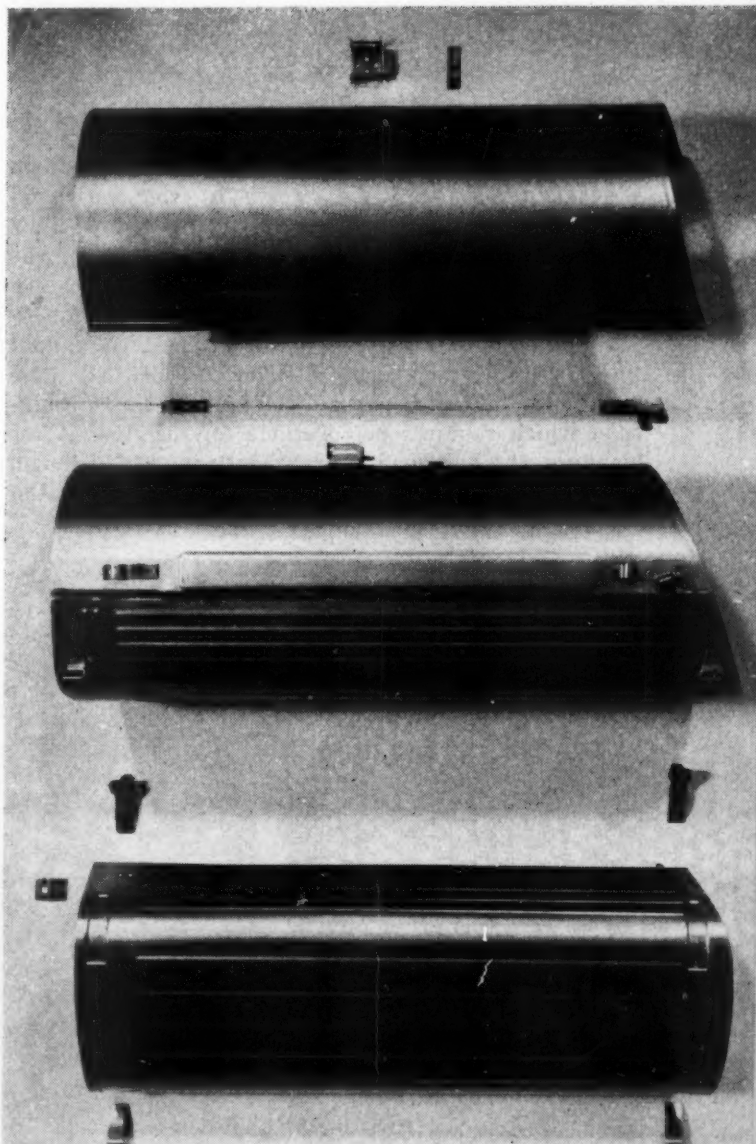
Locating Parts Without Jigs

DESIGN of spot welded sheet steel assemblies is frequently limited by the difficulty of locating parts accurately and quickly and at low cost. Locating jigs of sufficient rigidity are usually heavy and awkward to handle and must be continuously checked for wear. Their use can be entirely eliminated and production much accelerated by designing both the major and minor components of an assembly for self-location by means of depressions and by embossed locating buttons with matching locating holes or dimples in the mating piece.

An example of this is the Electrolux vacuum cleaner body assembly shown accompanying. In the forming operations a number of semispherical projections are formed in the steel sheets. The forming operation primarily embosses the stiffening ribs near the side edges of the sheet and the added locating bosses require no extra handling and little extra tool cost. After the operation, the body upper half is rolled into the shape shown.



Above and below the body upper half are shown the parts to be spot welded to the top and two of the four parts welded to the sides. It will be noted that each part has two round holes of the proper diameter for locating over the bosses. This permits spot welding to accurate location without use of locating fixtures or jigs.

At the bottom in the illustration is shown the body lower half. Two small brackets, like one shown at the left, are located with bosses and holes, as are the upper half parts. Four other brackets, for mounting the sleighs or runners, are located by depressions into which they are inserted for welding. Originally, each of these sleigh brackets was in two pieces, sepa-

rately located in a fixture. Redesigned as one piece, the brackets are now fabricated in a single operation on a four-slide machine, as are most of the other brackets shown.

The complete body before bonderizing and painting is shown at the center. The two halves, upper and lower, are welded together on a specially designed double automatic seam welder before the clips and brackets are spot welded to the body assembly. Elimination of the welding jigs in favor of the locating holes and bosses reduced the actual labor time of attaching the eight brackets by some 34 per cent.

Combining of the sleigh brackets into single stampings and accurately locating in depressions without fixtures reduced the labor time for this operation 22 per cent, exclusive of the saving in fabricating single brackets instead of separate half brackets. In addition to the direct saving, the parts were more accurately located and much additional time was saved on the assembly line, both in ease of part locations and in reduced repair and rework time.

Simplifying Die Design

AT THE left in the accompanying illustration is shown the original design (a conventional geometrical pattern layout of holes in the blanks) for a bulkhead which requires perforations for air flow. After blanking, the bulkhead is drawn into the shape shown at the extreme right. In the regular pattern of the original design the holes were kept small in size to minimize distortion in the subsequent forming.

The shearing load of many small blanking punches was heavy, and limited capacity of available presses made it necessary to perform perforating and blanking in separate operations. Both die cost and labor cost were high.

When it became necessary to rebuild the die, product and tool designers co-operated and found it possible to reduce the number of holes to approximately half the quantity by using larger sized holes, with no reduction in equivalent area, and to so arrange the hole layout as to avoid the ribs and highly stressed areas of the subsequent drawing operation. New hole layout is shown in the center of photo.

The larger size of the ventilating holes reduced their total perimeter 33 per cent, and therefore reduced the shearing load sufficiently to permit combining the piercing and blanking in a single two-station die by stepping the punches in the piercing and the blanking stations so that the first and second stations' cutting loads were not acting at the same instant.

Here is the operation sequence for both designs:

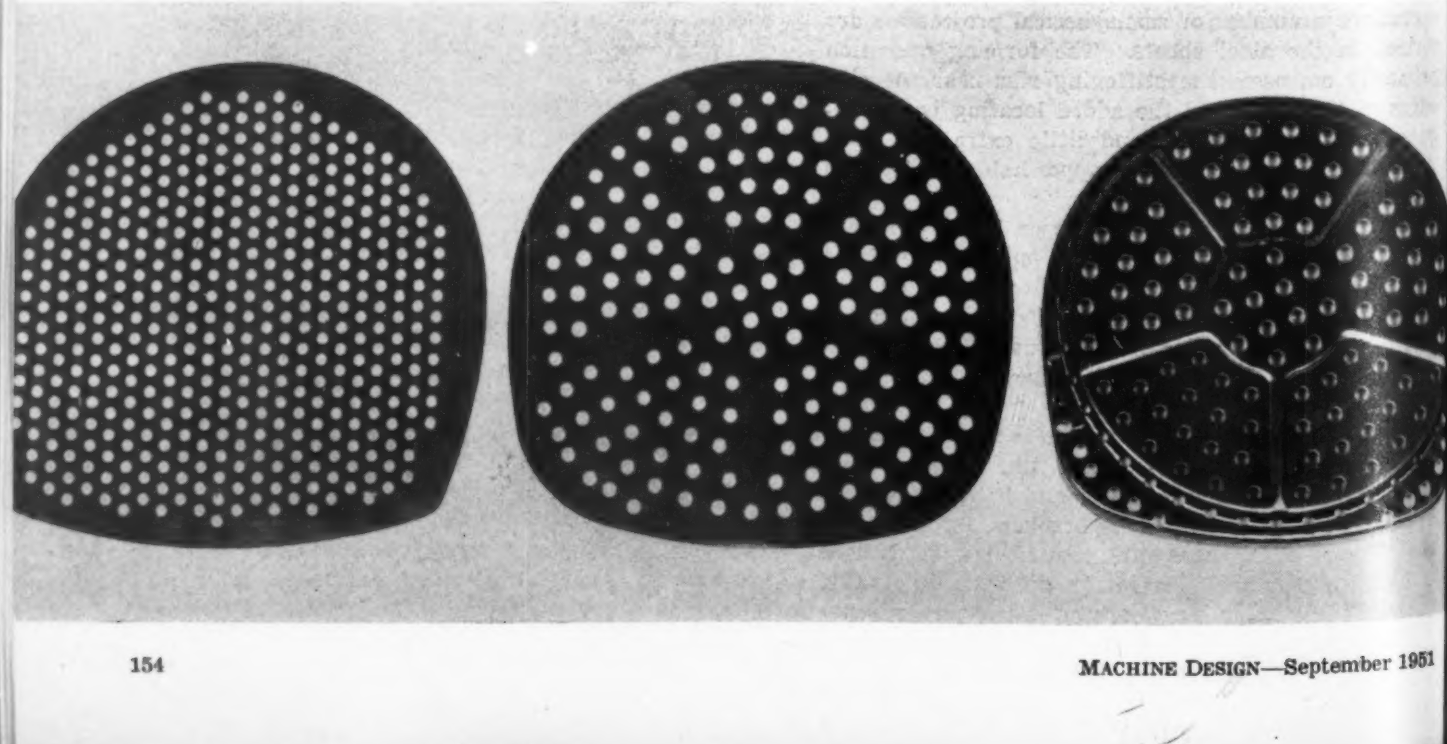
Old Method

1. Pierce in approximately 10-foot strips and stack on trucks
2. Blank
3. Draw and form to shape.

New Method

1. Pierce and blank (progressive die for coil stock)
2. Draw and form to size.

The new design gives die runs four times as long as the original. Die cost was reduced approximately 50 per cent and die upkeep $500 per year. Yearly saving in press room direct and indirect labor only was over $5,000 per year.



Gear Eccentricity

. . . how to predict its effect on angular displacement

By Richard L. Thoen

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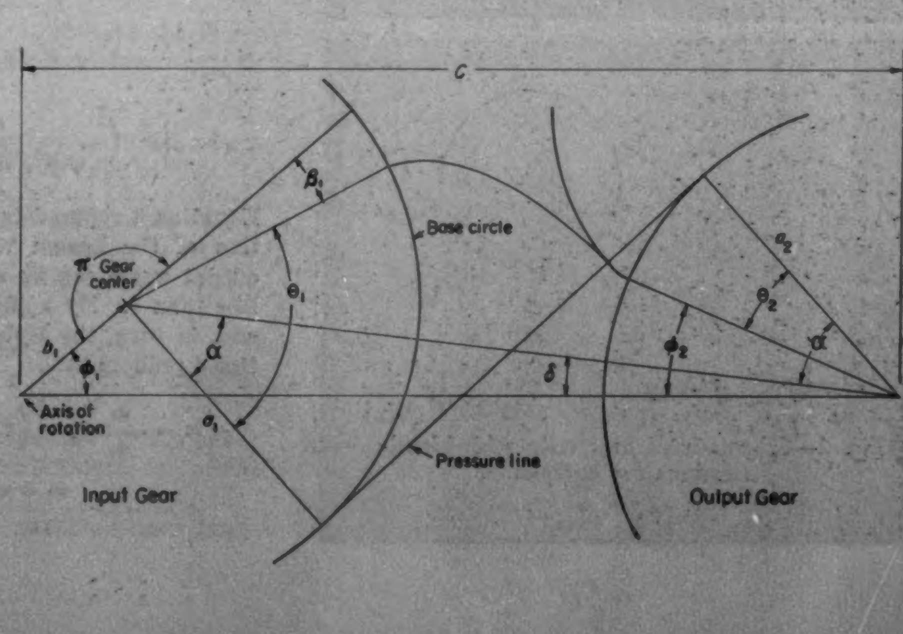
POSITIONING a shaft within a certain angular tolerance is a problem that often arises in the design of servomechanisms, mechanical computing devices and instruments in general. When spur gears are employed as a means of positioning, one of the common sources of angular error is eccentricity of the gears. This is particularly true for gears of small diameter.

When a high degree of positional accuracy is required, the runout tolerance must necessarily be low in magnitude. Often practical limitations, such as bearing runout and inaccuracies in hobbing, establish a runout greater than that desired and the only alternative is to increase the gear diameters. On the other hand, the physical size of the unit may have a limiting space dimension and then, as in so many

Fig. 1 — Relationships that exist between an eccentric input gear and a concentric output gear



engineering problems, a compromise is in order. Thus, the advantage of being able to predict the magnitude of the angular error as a function of runout becomes evident.

This discussion illustrates a method of calculating the angular error due to eccentricity in spur gears. It follows that the backlash at any point is the difference between the angular errors noted for clockwise and counterclockwise rotations. A procedure for minimizing angular errors due to eccentric gears of the same frequency is given in the later part of the discussion.

For simplicity, formulas will be derived for an eccentric gear mating with a concentric gear. When both gears are eccentric, the angular errors can be added algebraically. From *Fig.* 1,

Nomenclature

Units: length, inches; angles, radians unless otherwise noted)

a = Base circle radius
b = Separation between gear center and axis of rotation
c = Actual center distance
c_0 = Nominal center distance
Δc = Change in center distance
N = Number of gear teeth
P = Diametral pitch
R = Total indicator reading
S = Angular error spread
α = Instantaneous pressure angle
α_0 = Nominal pressure angle
β = Angle formed by a line extended from the axis of rotation through the gear center and a line from the gear center to the origin of the involute in contact
γ = Angular displacement between the high points of two gears rotating at the same speed
δ = Angle (see *Fig.* 1)
θ = Angle (see *Fig.* 1)
ϕ_1 = Input angle
ϕ_2 = Output angle
$\Delta\phi_2$ = Output angular error

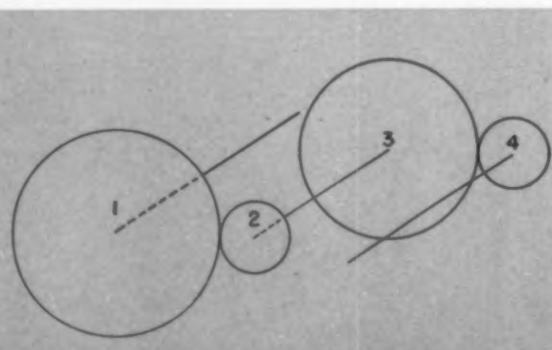


Fig. 2—Schematic of gear train with identifications for analysis

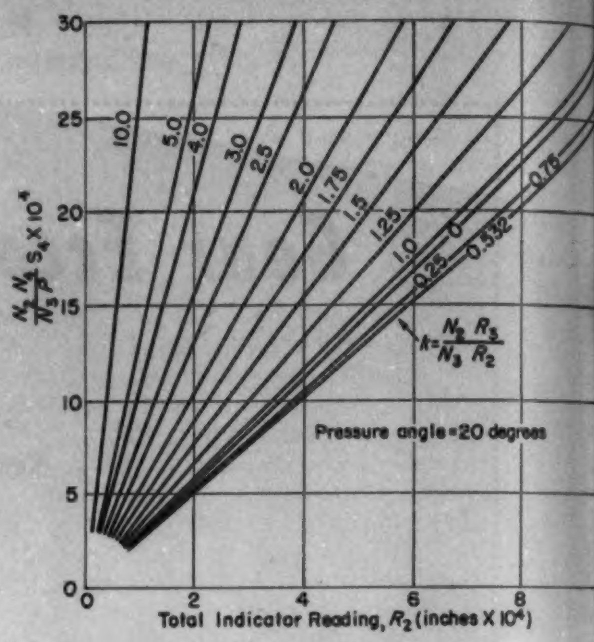


Fig. 3—Error spread factor versus various combinations of runout in two gears rotating at the same speed and so mounted that the high points mesh simultaneously

$$\phi_2 = \alpha + \delta - \theta_2 \qquad (1)$$

where

$$\theta_2 = \left(1 + \frac{a_1}{a_2}\right)\tan\alpha - \frac{a_1}{a_2}\theta_1 \qquad (2)$$

$$\theta_1 = \phi_1 + \alpha + \delta - \beta_1 \qquad (3)$$

Substituting Equations 2 and 3 in 1,

$$\phi_2 = -\frac{a_1}{a_2}\beta_1 + \left(1 + \frac{a_1}{a_2}\right)\delta + \frac{a_1}{a_2}\phi_1 - \left(1 + \frac{a_1}{a_2}\right)(\tan\alpha - \alpha) \qquad (4)$$

where

$$\delta = \sin^{-1}\left(\frac{b_1 \sin\phi_1}{\sqrt{c^2 + b_1^2 - 2cb_1\cos\phi_1}}\right) \qquad (5)$$

$$\alpha = \cos^{-1}\left(\frac{c_0\cos\alpha_0}{\sqrt{c^2 + b_1^2 - 2cb_1\cos\phi_1}}\right) \qquad (6)$$

Equation 4 represents the output angle ϕ_2 as a function of the known values. This expression for the output angle can be simplified since b_1 is very much less than c. By application of the binomial theorem and, in turn, the series expansion for the sine Equation 4 reduces to

$$\phi_2 = -\frac{a_1}{a_2}\beta_1 - \left(1 + \frac{a_1}{a_2}\right)\tan\alpha_0 + \left(1 + \frac{a_1}{a_2}\right)\alpha_0 + \frac{a_1}{a_2}\phi_1 - \frac{a_1 + a_2}{c_0}\frac{b_1}{a_2}\left(\tan\alpha_0 - \frac{\sin(\phi_1 + \alpha_0)}{\cos\alpha_0}\right) \qquad (7)$$

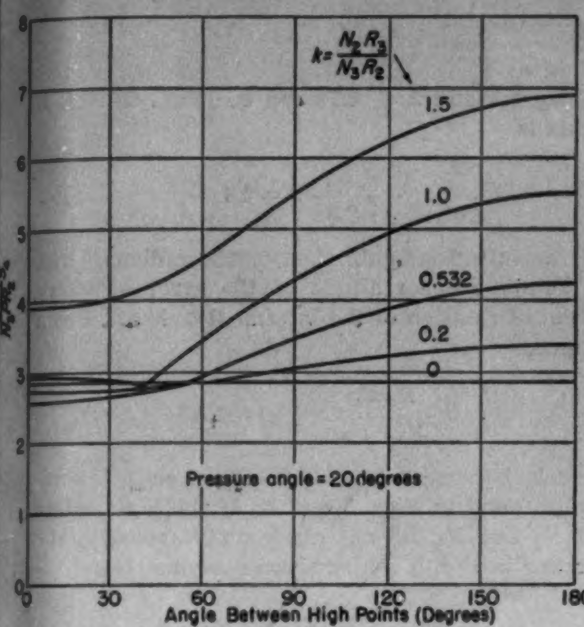


Fig. 4—Error spread factor versus various combinations of runout and timing in two gears rotating at the same speed

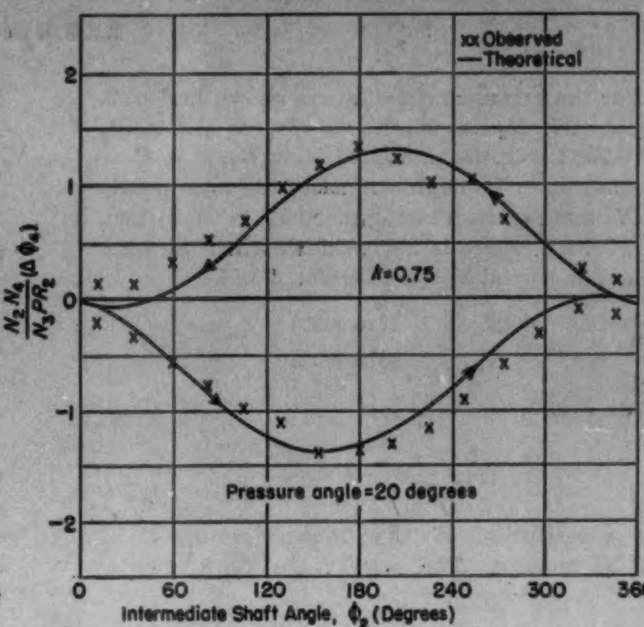


Fig. 5—Output angular error versus intermediate shaft angle for two gears rotating at the same speed and so mounted that the high points mesh

where $c_0 = c - b_1$. That is, it has been assumed that the center distance is such that there is no backlash when the high point of the eccentric gear is in mesh.

If there were no eccentricity, the last term in Equation 7 would be absent. Therefore, it is this term that represents the angular error due to the eccentricity of the input gear. Since $(a_1 + a_2)/c_0 = \cos\alpha_0$, $a_2 = (N_2/2P)\cos\alpha_0$, and $2b_1 = R_1$, the angular error can be expressed as

$$\Delta\phi_2 = -R_1 \frac{P}{N_2} \tan\alpha_0 + R_1 \frac{P}{N_2 \cos\alpha_0} \sin(\phi_1 + \alpha_0) \quad (8)$$

Examination of Equation 8 shows that the angular error consists of a constant value upon which is superimposed a sinusoidal quantity. Usually it is the total spread, $S = 2(\Delta\phi_{2max})$, that is of interest. The factor $\Delta\phi_{2max}$ can be found by setting $\phi_1 = (3/2\pi - \alpha_0$ in Equation 8. Then the runout tolerance can be determined by solving for R_1.

$$R_1 = \frac{N_2}{2P} \frac{\cos\alpha_0}{1 + \sin\alpha_0} S \quad (9)$$

When the center distance is greater than $c_0 + b_1$, the additional spread due to the increase in center distance, Δc, can be found by setting $\phi_1 = \pi$ and $R_1 = \Delta c$ in Equation 8.

$$S_{\Delta c} = 4(\Delta c) \frac{P}{N_2} \tan\alpha_0 \quad (10)$$

Incidentally, multiplying Equation 10 by the pitch radius, $N_2/2P$, gives the familiar formula for pitch line backlash, $2(\Delta c)\tan\alpha_0$.

Similarly, for the case of an eccentric output gear and a concentric input gear, it can be shown that the angular error at the output shaft is

$$\Delta\phi_2 = -R_2 \frac{P}{N_2} \tan\alpha_0 - R_2 \frac{P}{N_2 \cos\alpha_0} \sin(\phi_2 - \alpha_0) \quad (11)$$

and that the runout tolerance can be determined from

$$R_2 = \frac{N_2}{2P} \frac{\cos\alpha_0}{1 + \sin\alpha_0} S \quad (12)$$

Opposed Errors Minimize Deviation

The angular error at the output shaft of a train of eccentric gears can be determined by applying Equation 8 or 11 to each gear, depending upon whether the gear is an input or output gear, and then adding all the terms algebraically. It can be seen that the gears which rotate at the same speed can be made to contribute their errors in opposition and thereby minimize the error at the output shaft. For example, when the center distances in *Fig.* 2 are such that there is no backlash when the high points of the mating gears are in mesh,

$$c_{1\text{-}2} = \frac{1}{2}\left(\frac{N_1 + N_2}{P} + R_1 + R_2\right)$$

and

$$c_{3\text{-}4} = \frac{1}{2}\left(\frac{N_3 + N_4}{P} + R_3 + R_4\right)$$

Then, for the case in which input information is fed to gear 1 in both clockwise and counterclockwise directions, the overall spread at shaft 4 due to ec-

Example

For the arrangement of gears shown in *Fig.* 2, $N_2 = 27$, $N_3 = 90$, $N_4 = 24$, $R_1 = 0$, $R_2 = 0.0002$ inch, $R_3 = 0.0005$ inch, $R_4 = 0$, $P = 80$, and $\alpha_0 = 20$ degrees. Also, the high points of N_2 and N_3 mesh simultaneously ($\gamma = 0$) and, in addition, there is no backlash when the high points of N_2 and N_3 are in mesh. First,

$$k = \frac{N_2 R_3}{N_3 R_2} = \frac{27(0.0005)}{90(0.0002)} = 0.75$$

From *Fig.* 3,

$$\frac{N_2 N_4}{N_3 P} S = 0.00053$$

By substitution of the known values, $S = 0.0059$ radians. The same value for S at $\gamma = 0$ degrees and $k = 0.75$ can be found in *Fig.* 4. That is,

$$\frac{N_2 N_4}{N_3 P R_2} S = 2.6$$

By substitution again, $S = 0.0059$ radians. *Fig.* 5 shows the magnitude of the error at every point of rotation of the intermediate shaft. From *Fig.* 5,

$$\frac{N_2 N_4}{N_3 P R_2} \Delta\phi_{4max} = 1.3$$

which, because $\Delta\phi_{max} = S/2$, agrees with the results found in *Figs.* 3 and 4. If the high points of N_2 and N_3 did not mesh simultaneously, the curves in *Fig.* 5 would become asymmetrical.

centricity in gears 2 and 3 will be

$$S = \frac{P}{N_4 \cos \alpha_0} \left\{ 2\left(\frac{N_3}{N_4} R_2 + R_3\right) \sin \alpha_0 + \left[\left(\frac{N_3}{N_2} R_2\right)^2 - 2\frac{N_3}{N_2} R_2 R_3 \cos(\gamma + 2\alpha_0) + R_3^2\right]^{\frac{1}{2}} + \left[\left(\frac{N_3}{N_2} R_2\right)^2 - 2\frac{N_3}{N_2} R_2 R_3 \cos(\gamma - 2\alpha_0) + R_3^2\right]^{\frac{1}{2}} \right\} \quad (13)$$

Equation 13 passes through a minimum when the two conditions represented by Equations 14 and 15 are met; that is, when

$$\gamma = 0 \quad (14)$$

and

$$R_3 = \frac{N_3}{N_2} \frac{\cos 3\alpha_0}{\cos \alpha_0} R_2 \quad (15)$$

Substituting Equations 14 and 15 in 13,

$$S_{min} = 4P \frac{N_3}{N_2 N_4} \sin 2\alpha_0 R_2 \quad (16)$$

Thus, for two gears rotating at the same speed, if the high points are mounted so as to mesh simultaneously and if the runouts are proportioned correctly, the error spread will then be a minimum.

A plot of Equation 13 is shown in *Fig.* 3 for the condition in which $\gamma = 0$ and $\alpha_0 = 20$ degrees. *Fig.* 4 illustrates how the error spread increases when the high points do not mesh simultaneously. From *Fig.* 4 it can be seen that about the same minimum will be obtained over the range of $0 < \gamma < 40$ degrees providing $k <$ unity. In the event that the center distances were greater than those stated at the beginning of the example, the additional error spread would be determined from Equation 10.

Equation 8 and 11 are useful for analyzing error data taken on gear trains. Theoretical curves can be drawn or at least the peaks of the error curves can be located with respect to an arbitrary reference point on each of the gears. With a knowledge of the errors due to eccentricity it is possible to differentiate between eccentric errors and errors due to other types of gear inaccuracies. For example, it can be shown that a sinusoidal distribution of tooth spacing error is difficult to detect in a roll test; however, errors in tooth spacing would probably show up on an error plot. That is, the reference point would not agree with the peaks of the error curves and also a greater error spread than that calculated for eccentricity only would appear.

It will be found that the fundamental relationships stated in Equations 8 and 11 can be manipulated to give an expression for the angular error produced by any combination of eccentric spur gears.

They Say...

"The engineer's works are out in the open where all men can see them. He cannot deny he did it. The doctor's mistakes are buried in the grave. The voters forget when the politician changes the alphabetical names of his falling projects. Trees and ivy cover the architect's failures. The lawyers can blame the judge or the jury. Unlike the clergyman, the engineer cannot blame his failures on the devil."—HERBERT HOOVER.

"Management skill known as standardization is one of the most important reasons that we in the United States, despite our numerical inferiority, can look forward with some hope of the future. We must not wait until we are deeper in an emergency to do the job of standardization that still needs to be done in industry and government. The factors are increasing against us as time goes on."—BRIG. GEN. DONALD ARMSTRONG, *U.S.A. (retired), president, U. S. Pipe & Foundry Co.*

WEB GUIDING CONTROL

. . . provides accuracy at high speeds

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IN HANDLING web materials, the best operating economics result when the largest practical size mill rolls are used at high web speeds. However, these increased sizes and speeds have made it more difficult to guide or track the web accurately through processing machines. In some operations it is necessary to hold the edge runout to tolerances of the order of ±1/32-inch or less. This article covers development and testing of equipment for this purpose, *Fig.* 1, and is sufficiently complete to enable a designer to duplicate the work.

In a recently considered web guiding installation, the combined unwinder stand together with mill rolls weighed more than three tons. The inertia and frictional forces inherent in a combination of this magnitude make it apparent that it would be impractical to expect to hold the sway or runout of the web to close tolerances. *Fig.* 2 shows a graph of the relationship of lineal web speed to time of response. To hold the edge of the web to within ±1/32-inch at a lineal speed of 1500 feet per minute, the speed of response would need to be of the order of ⅛-second, based on a 3-foot span between unwinding roll and processing machine. Heavier masses would require more time to move and would decrease the response as shown by the graph. For example, if the time to effect movement of the mass were as long as 1½ sec, the lineal speed would be only 100 fpm, emphasizing that to attain precise web guiding at high lineal web speeds, it is important to keep the over-all mass to be moved as small as possible. Since the masses in question must be small to obtain precise guiding at high lineal web speeds, it is obvious that the solution of the problem lay in moving only the web to effect accurate guiding.

A survey of patents shows many types of web shifting devices of this nature but none effectively shift the web promptly; most depend upon the web to go through the slow process of working its way over by means of belt action, etc. Many types utilize fingers and paddles running against the edge to actuate shifting devices, most of which require a relatively long span of web before and after the shifting roller to make them effective.

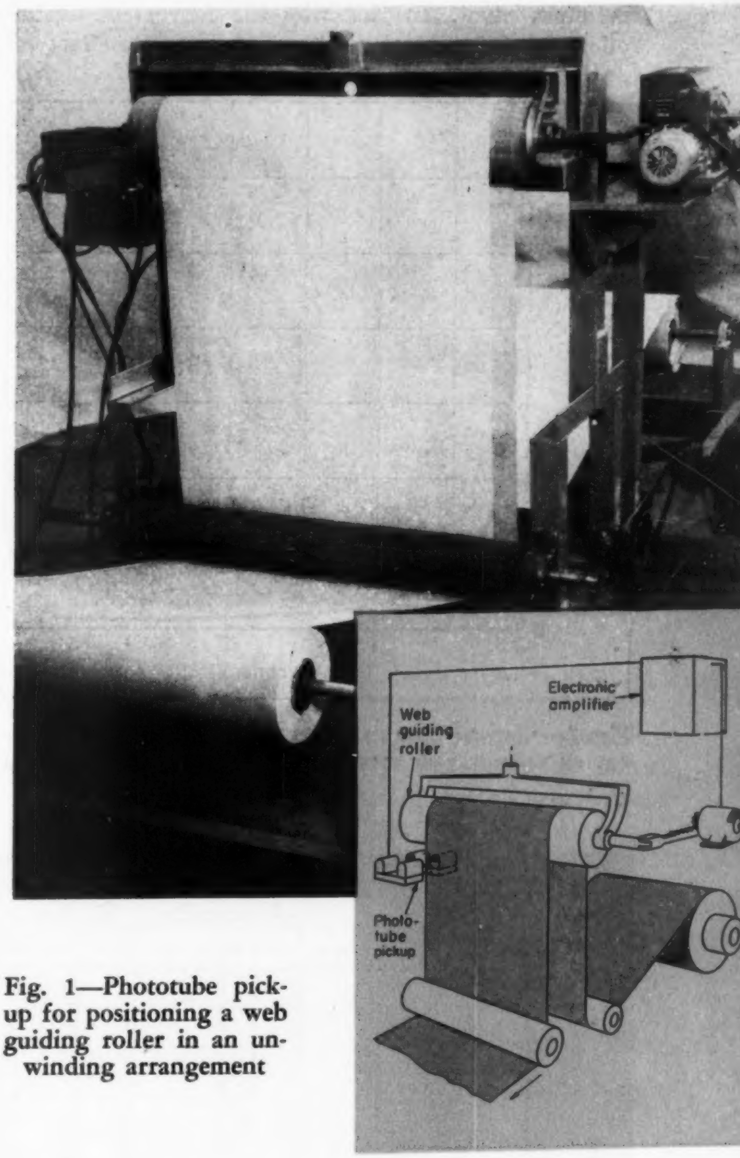

Fig. 1—Phototube pick-up for positioning a web guiding roller in an unwinding arrangement

Due to the impractical nature of such devices and resulting hunting difficulties, these web guiders are not in much demand in the industry. Consequently, most web guiding has been done by shifting the mill roll directly, which has also been unsatisfactory. The reason for this is obvious from the graph, *Fig.* 2, wherein the movement of the massive mill roll and associated equipment would give speeds of response of the order of seconds instead of the necessary fractions of seconds to attain high lineal speeds. In 1916 the first electrically operated and controlled mill roll shifter was patented. Many of these are in use today and are successfully operated at lower lineal speeds. Recent installations are equipped with electronic controllers, and are able to hold the sway to within ±1/16-inch at approximately 500 fpm where the

transverse rate of runout is not great.

A light-weight offset pivoted web guiding roller was developed in 1946 for this purpose as a result of these findings and proved satisfactory as an effective means for shifting the web of material. *Fig.* 1 shows such a roller together with an electric eye sensing element, electronic amplifier, and low-inertia motor arranged to shift the web guiding roller about its offset pivot. In this way the movement of the roller about its offset pivot will have little effect on

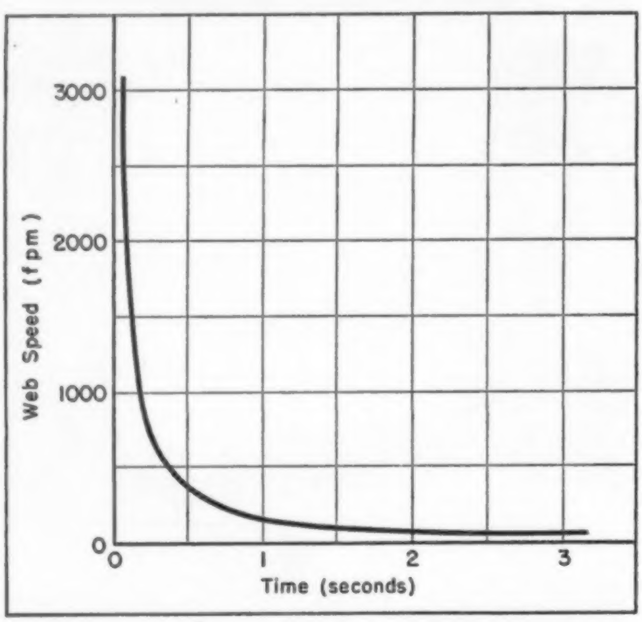

Fig. 2—Elapsed time to correct for 1/32-inch edge runout at various web speeds, based on a three-foot span

the oncoming web, but will effectively and rapidly shift the off-going part of the web transversely, the degree of shift of the web being a function of the diameter of the roller. For large installations, two small rollers would be used instead of the single large-diameter roller to keep the mass of the component parts as low as possible.

In *Fig.* 3 is shown how the offset pivoted web guiding roller operates to shift only the web of material transversely. View *A* shows an unwinding web of material passing around a roller and then over the offset pivoted web guiding roller and around another roller into the process. The offset pivot axis of the roller is in line with the oncoming web to prevent the roller from shifting the web on the oncoming side. The web then makes an angle of 180 degrees around the roller and into the processing machine. The extent to which the off-going web will be transversely shifted when the roller is moved about its offset pivot will be observed to depend upon the diameter *D*.

View *B* shows in plan view the web aligned at *M*. If the web, due to an unevenly wound mill roll, moves to *N*, the guide roller is shifted about its offset pivot, as shown in view *C*, to realign the off-going edge to its original line at *M*. *Fig.* 4 illustrates the mechanics of how such an offset pivoted roller can rapidly and effectively move the web of material. The web of material—passing around the idler roller *A*, pivoted roller *B* and the idler roller *C*—is laid in a straight line *A′*, *B′*, *C′*. Projection to *A″*, *B″*, *C″* shows the web flat as represented by a strip of material. If the strip is pivoted at *A″* and moved to the position *B‴*, *C‴*, the distance moved at *C‴* is much greater than the distance moved at *B‴*. Magnification of this

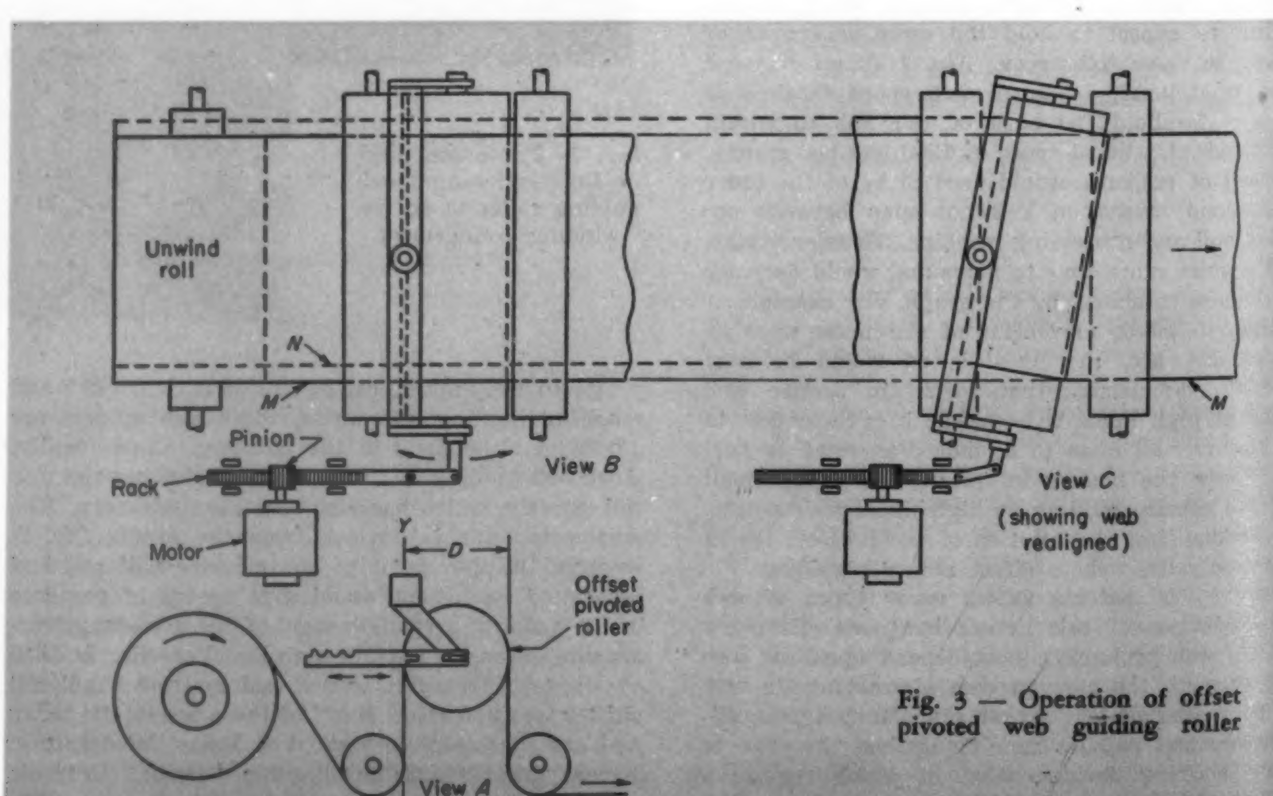

Fig. 3 — Operation of offset pivoted web guiding roller

movement takes place when the pivoted web guide roller is operated, thus accounting for the rapidity with which the roller moves the edge of the sheet of material to correct for runout of the edge of the web.

It will be evident that it would not be practical to shorten the length A'' to C'' and likewise lengthen B''' to C''' to increase the ratio of magnification, since a reasonable length of span is required to prevent throwing wrinkles in the on and off sides of the web.

The offset pivoted web guiding roller used in the test was 6 inches in diameter by 36 inches in length and handled a ¾-inch total web runout, although runout corrections as much as 2 inches may be handled on larger installations by increasing the diameter *D*, *Fig.* 3. Where it may be desirable to control sway or runout of greater magnitude, the unwinding mill roll should be shifted by the use of a conventional web guider to keep the runout approximately within the range of the faster operating offset pivoted roller. Limit switches can be utilized from the offset pivoted roller to cause the mill roll to be shifted when necessary. A simple arrangement can be worked out for this purpose.

Hydraulic and pneumatic controllers were first tried, but were only fast enough for operating the web guiding roller at approximately 600 fpm lineal web speed to remain within the tolerance of $\pm 1/32$-inch. The slow actuation was due to the slower response of this type of equipment. However, effective antihunting was worked out and demonstrated using the pneumatic equipment. In particular, an integral antihunting device was used with the pneumatic controller that made a low-cost control effective for use with either mill roll guiding or with the offset pivoted web guiding roller for low lineal speeds. Hydraulic devices are inherently stable, and no hunting difficulties were experienced with this equipment.

Antihunt Devices Were Available

To obtain precise web guiding at much higher lineal speed, it became apparent that control and actuating components having the lowest inertia and friction would be needed to operate the light-weight web guiding roller. In addition, effective antihunting would be required. Because the Armed Forces have made effective use of servomechanisms in fire control apparatus, it was thought that satisfactory antihunt devices must have been developed. A search of the literature disclosed that low-inertia motors are used where high response is required and that some ingenious antihunt devices have been worked out, particularly for electronic circuits.

An electronic circuit of conventional design was developed for testing and is shown in *Fig.* 5. It utilizes phototube sensing elements to drive a low-inertia type motor. Two photoelectric tubes form a bridge, two tubes being required for use on cellophane to cancel effect of birefringence and the effect of opaque mends passing the electric eye. Another advantage of two phototubes is the neutralizing effect of ambient and stray light as well as the reducing of line voltage variations.

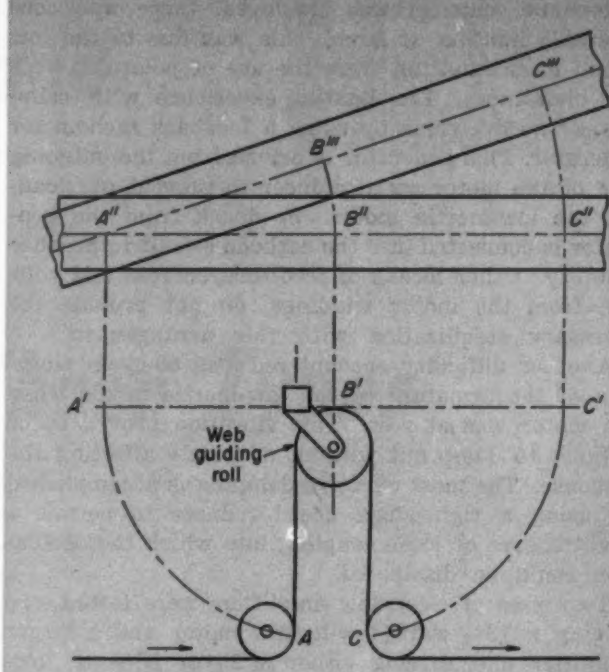

Fig. 4—Diagram showing how pivoting the web guiding roller effectively shifts the web

The tubes are arranged for proportional response which has advantage over on-and-off sensing elements. Another advantage is the use of direct-current in the bridge which not only assures better stability and response but also permits use of better error-rate response. The remainder of the circuit is conventional. Alternating-current is introduced in the plate circuit of the 6SN7 tube of the bridge and is alternating-current operated from there on. An improvement in this circuit would be to use Type 807 tubes for 220-volt motor operation.

Opaque mends on cellophane affect the two phototubes equally. When the two tubes and light sources are covered with oriented polaroids, light passes only when cellophane is interposed between the tubes and the light sources. Cellophane has the faculty of reorienting light rays when they are cut off by polaroids. One tube is located entirely within the web of cellophane and the window half covered by an opaque shutter. The other tube is located so that the edge of the cellophane half covers the opening.

In this way equal amounts of light pass to each tube and no differential currents flow in the bridge circuit. Thereafter, any movement of the edge of the cellophane to cover or uncover the signal tube unbalances the bridge by letting in more or less light and causes a differential current to flow. When opaque mends pass both tubes simultaneously, provided the system is in balance, the effect on each tube is again the same with no differential current flowing. The opaque mends made it appear as though no cellophane were between the light sources and the phototubes.

When opaque materials were guided in the test

setup, no hunting difficulties were encountered. When cellophane material was employed, there was considerable hunting at first. This was due to the low signal level resulting from the use of polaroids with the phototubes. The hunting experience with cellophane was overcome by using a feedback tachometer generator. This generator is driven from the outgoing side of the motor speed reducer to prevent overloading the low-inertia motor. Feedback from the generator is connected into the cathode circuit to produce stability. Other means of feedback, current and voltage from the motor windings, do not provide the necessary stabilization with this arrangement.

Another difficulty encountered was 60-cycle vibration of the armature of the low-inertia motor when the motor was at rest. This vibration proved to be difficult to damp out without adversely affecting the response. The most effective damping is accomplished by using a right-angle speed reducer to permit a slight degree of loose coupling into which the oscillation could be dissipated.

Two sizes of electronic amplifiers were tested, one driving a 13½-watt, low-inertia motor and a larger amplifier unit driving either a 25 or 50-watt, low-inertia motor. The accompanying tabulation shows the performance using a cellophane web.

In all instances the total runout is held within ±1/32-inch. At 625 fpm web speed, the transverse rate of runout for which the roller corrected within the tolerance, is 68 inches per minute. At 925 fpm lineal speed, this same unit has a transverse rate of 25 inches per minute. Maximum transverse rate of runout for the 25-watt, low-inertia motor at 1225 fpm is 40 inches per minute and 22.5 inches per minute for the 50-watt, low-inertia motor at 1430 fpm. It will be observed that these transverse rates of runout are much higher than those obtainable by other means, considering the close tolerance of ±1/32-inch to which the edge of the web must be held.

To attain high-speed web guiding, low-inertia components must be used throughout, as well as highly responsive control and sensing elements. If more power is needed, it must not be obtained at the expense of response or the purpose will be defeated. Once the transverse rate of runout and the runout limits are known, the inertia of the components should be calculated to determine the response. It is also important to keep friction as low as possible and to avoid the use of components that would load the moving elements, lowering over-all performance.

Maximum Web Speeds for Three Motors

Low-Inertia (watts)	Web Speed (fpm)	Max. Edge Runout (inch)	Transverse Runout (in./min)
13.5	625	$\pm\frac{1}{32}$	68
	925	$\pm\frac{1}{32}$	25
25	1225	$\pm\frac{1}{32}$	40
50	1430	$\pm\frac{1}{32}$	22½

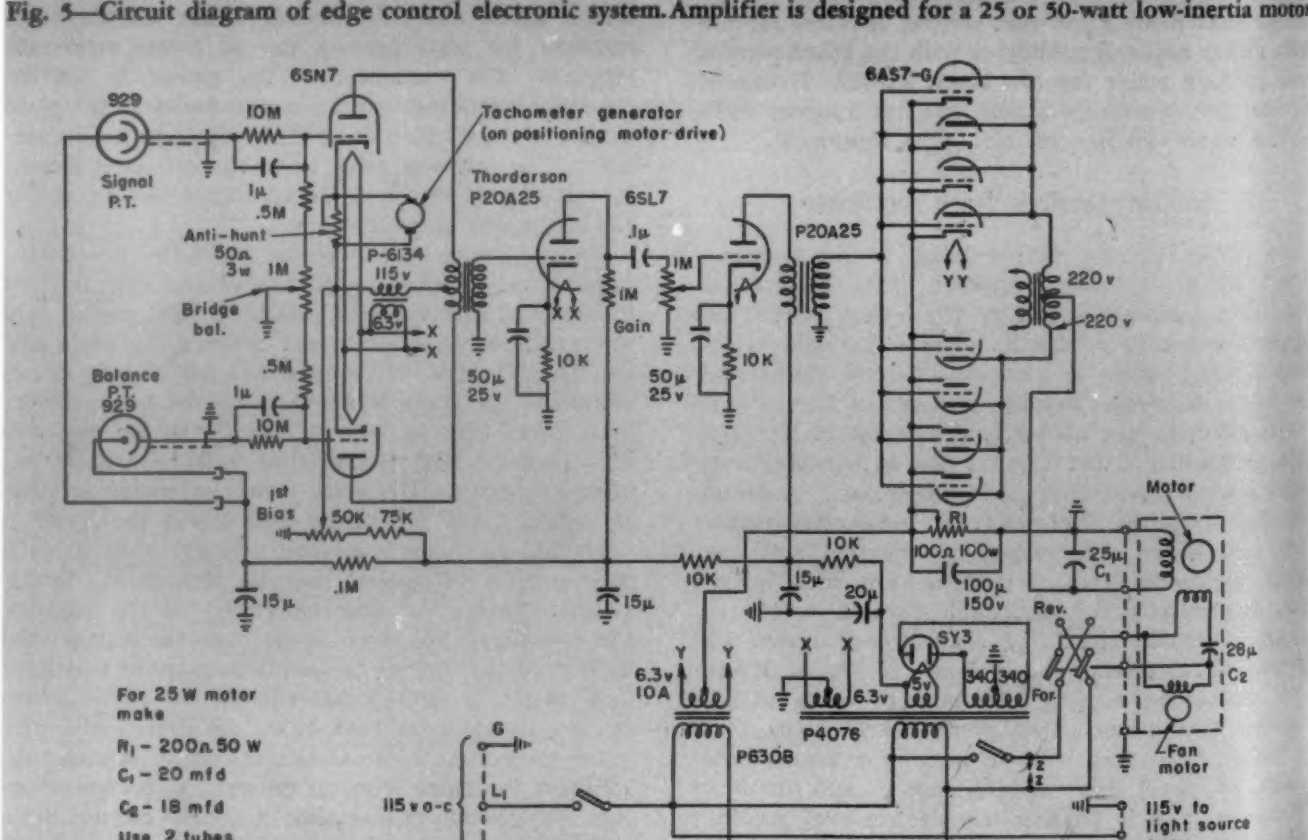

Fig. 5—Circuit diagram of edge control electronic system. Amplifier is designed for a 25 or 50-watt low-inertia motor

Analyzing Stress and Deflection for Plates of Three Types

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SIMPLIFIED analyses of thin plates of several shapes and sections and different loading conditions, are presented in this article. Designations, factors analyzed, and specific conditions for these cases are as follows:

1. *Stretched Rectangular Plate*: Deflection and stress in a simply supported, uniformly surface loaded rectangular plate subjected to uniform tensile force along two opposite edges
2. *Stretched or Compressed Circular Plate*: Deflection and stress in a uniformly loaded circular plate subjected to radial tensile or compressive forces completely around the rim. Edge clamped and edge simply supported are considered
3. *Tapered Circular Plate*: Stress in a circular plate tapering linearly outward, clamped at an inner diameter, and subjected to uniform surface loading or uniform axial outer edge loading.

Solutions can be obtained rapidly from graphs or tabular data included in each of the following sections.

Stretched Rectangular Plate: Data for the method outlined here for plates such as shown in *Fig.* 1 have been obtained from the small-deflection theory of plate bending. Therefore, the method is subject to the limitation that the maximum deflection must not exceed about one-half the plate thickness. The complete analysis has been presented elsewhere by the author.[1] The maximum deflection W_{max} occurs at the center of the plate and is given by

$$W_{max} = K_1 \frac{qB^4}{EH^3}$$

where K_1 is a constant, shown plotted against the plate side ratio A/B for various values of P/P_E in *Fig.* 2. Other terms are defined in the Nomenclature.

[1]References are tabulated at end of article.

The bending stress S_x at the center of the plate in the X direction is

$$S_x = K_2 \frac{qB^2}{H^2}$$

where K_2 is a constant, plotted in *Fig.* 3. The bending stress S_y at the center of the plate in the Y direction is

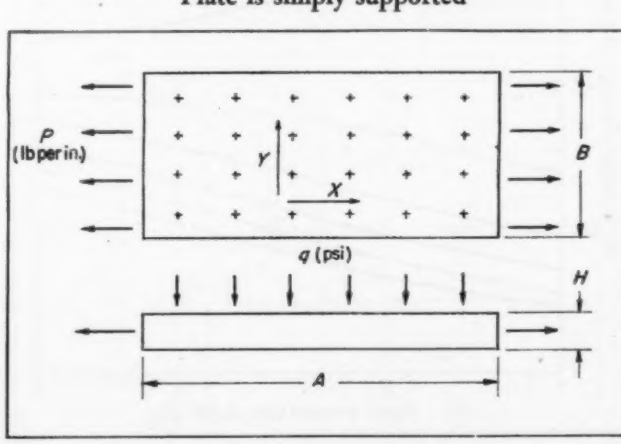
$$S_y = K_3 \frac{qB^2}{H^2}$$

where the constant K_3 is plotted in *Fig.* 4.

The maximum resultant stress in the X direction at the center of the plate is then $(P/H) + S_x$ and is tensile, while that in the Y direction is S_y, tensile or compressive.

For certain values of A/B and P/P_E, the maximum bending stresses do not occur at the center of the plate.[2] However, for the range of validity of the

Fig. 1—Loading conditions for a rectangular plate which is both stretched and uniformly surface loaded. Plate is simply supported



Data Sheet

graphs (in terms of ratio of maximum deflection to plate thickness) and for practical values of A/B and P, the maximum stress computed is sufficiently accurate for design purposes.

EXAMPLE: The following example illustrates how the graphs may be used. Data for a rectangular plate with tensile end load are as follows: length $A = 37.5$ inches, width $B = 25$ inches, thickness $H = 0.25$-inch, pressure $q = 2$ psi, tensile load $P = 2000$ lb per inch, modulus of elasticity $E = 30{,}000{,}000$ psi, Poisson's ratio $\nu = 0.3$.

Flexural rigidity D is first calculated:

$$D = \frac{EH^3}{12(1-\nu^2)} = 42{,}930 \text{ lb-in.}$$

Hence

$$P_E = \frac{4\pi^2 D}{B^2} = \frac{4\pi^2(42{,}930)}{25^2} = 2710 \text{ lb per in.}$$

and

$$\frac{P}{P_E} = \frac{2000}{2710} = 0.74$$

By interpolation from *Fig.* 2, the constant K_1 is 0.053, or

$$W_{max} = K_1 \frac{qB^4}{EH^3} = 0.053 \frac{2\,(25)^4}{30{,}000{,}000\,(0.25)^3} = 0.0883\text{-in.}$$

Since $W_{max}/H = 0.35$, the results appear to be within the range of validity of the theory.

By interpolation from *Figs.* 3 and 4, the constants K_2 and K_3 are 0.168 and 0.288, respectively. Hence, the maximum bending stresses at the center of the plate are

$$S_x = K_2 \frac{qB^2}{H^2} = 0.168 \frac{2(25)^2}{0.25^2} = 3360 \text{ psi}$$

and

$$S_y = K_3 \frac{qB^2}{H^2} = 0.288 \frac{2(25)^2}{0.25^2} = 5760 \text{ psi}$$

Since the longitudinal direct stress in the X direction is $2000/0.25 = 8000$ psi, the maximum resultant

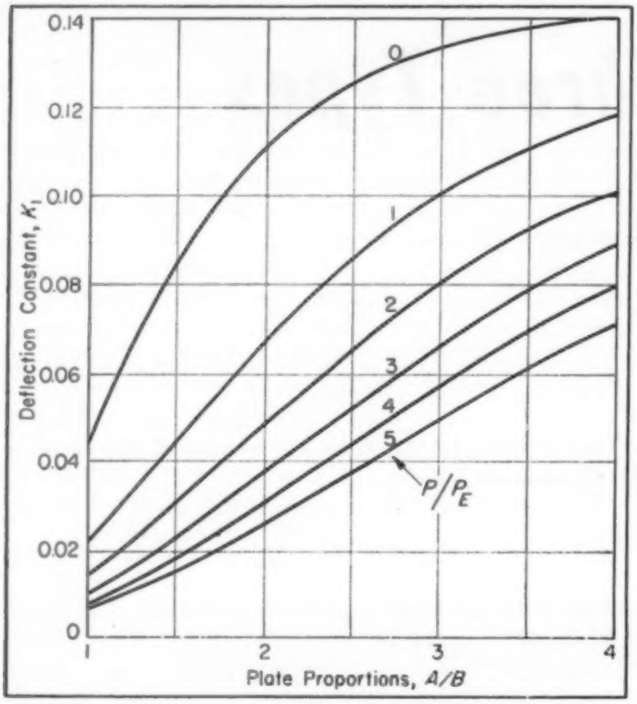


Fig. 2—Plate proportions versus deflection constant for stretched rectangular plate

Fig. 3—Plate proportions versus X-direction stress constant for stretched rectangular plate

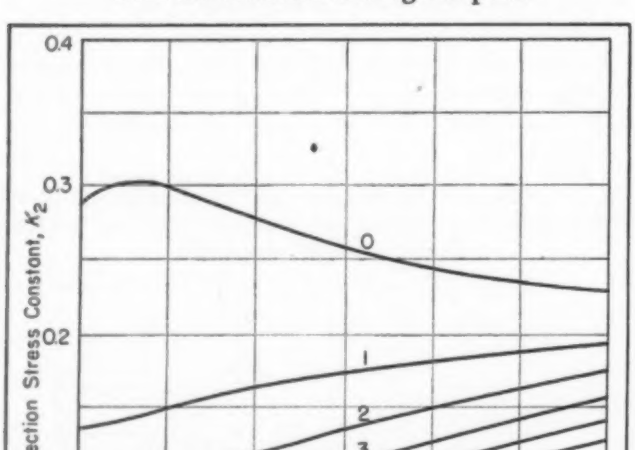
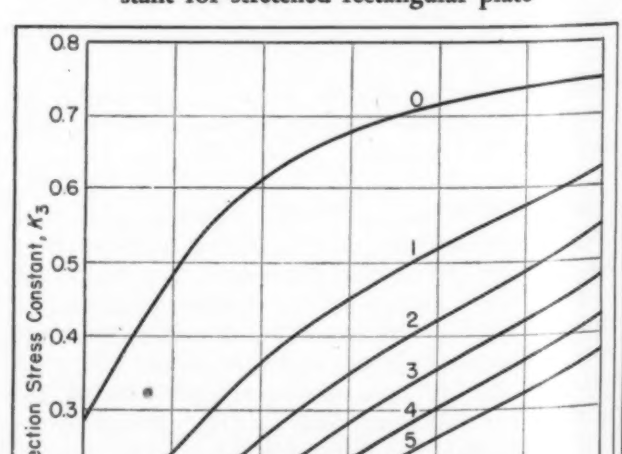


Fig. 4—Plate proportions versus Y-direction stress constant for stretched rectangular plate



stress in the X direction at the center of the plate is $8000 + 3360 = 11{,}360$ psi, tensile. The maximum resultant stress in the Y direction is, of course, 5760 psi, tensile or compressive.

Stretched or Compressed Circular Plate: Results for plates shown in ***Fig.*** 5 have also been obtained from the small-deflection theory of plate bending. The analysis involves ordinary Bessel functions for radial compression and modified Bessel functions for radial tension.

EDGE CLAMPED: For a uniformly loaded plate with a clamped edge and with zero radial load, the maximum deflection W is

$$W = \frac{qR^4}{64D}$$

The maximum bending stress S acts radially at the clamped edge and is given by

$$S = 0.75\, q \left(\frac{R}{H} \right)^2$$

For radial compressive or tensile loading P per unit length of circumference, the maximum deflection and bending stress are denoted W_{max} and S_{max}, respectively. Graphs showing the variation of W_{max}/W and S_{max}/S with CR are plotted in ***Fig.*** 6. These graphs become asymptotic to a line $CR = 3.832$ representing buckling of the plate. The maximum resultant stress in the plate is $(P/H) + S_{max}$.

EDGE SIMPLY SUPPORTED: For a uniformly loaded plate with a simply supported edge and with zero radial load, the maximum deflection W is

$$W = \left(\frac{5 + \nu}{1 + \nu} \right) \frac{qR^4}{64D}$$

Nomenclature

- A = Length of side of rectangular plate parallel to P, inches
- a = Outside radius of tapered circular plate, inches
- B = Length of side of rectangular plate perpendicular to P, inches
- b = Inside clamped radius of tapered circular plate, inches
- $C = \sqrt{P/D}$ (circular plate)
- D = Flexural rigidity $= E H^3/12\,(1 - \nu^2)$, lb-in.
- E = Modulus of elasticity, psi
- F = Total load applied axially along outside edge of tapered circular plate
- H = Thickness of rectangular or circular plate, inches
- h = Maximum thickness of tapered circular plate, inches
- K = Constant
- P = Load per unit width of rectangular plate or per unit length of circumference of circular plate, lb per inch
- $P_E = 4\pi^2 D/B^2$ (rectangular plate)
- q = Pressure normal to surface, psi
- R = Radius of circular plate, inches
- S = Bending stress, psi
- W = Deflection, inches
- ν = Poisson's ratio

Fig. 5 — Right — Loading conditions for a circular plate which is both stretched or compressed and uniformly surface loaded with edge clamped or edge simply supported

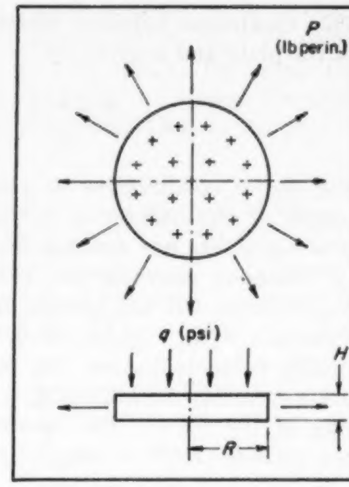


Fig. 6 — Below— Load - size factor versus deflection and stress ratios for circular plate with edge clamped

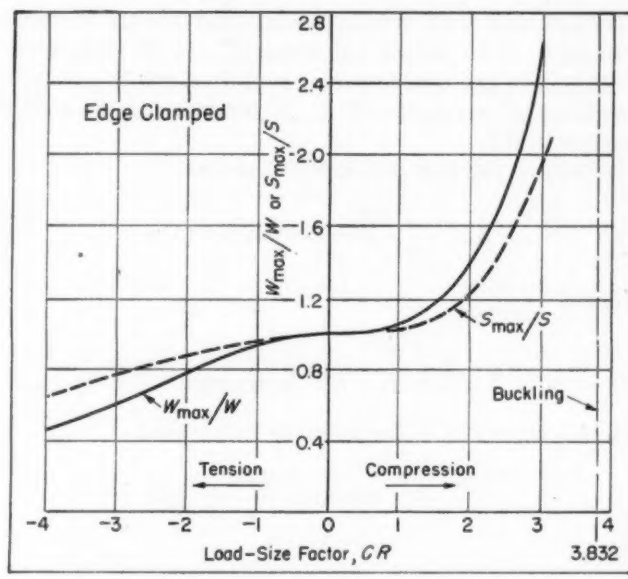
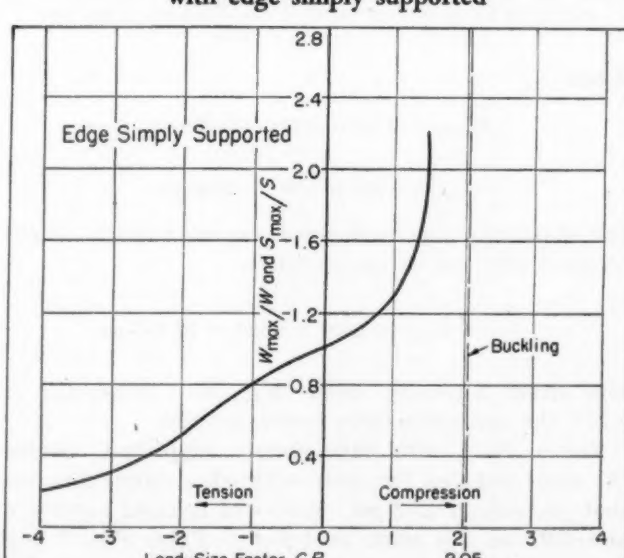


Fig. 7—Below—Load-size factor versus deflection and stress ratios for stretched or compressed circular plate with edge simply supported



Data Sheet

The maximum bending stress occurs at the center of the plate and is given by

$$S = \frac{3(3+\nu)}{8} q \left(\frac{R}{H}\right)^2$$

For radial compressive or tensile loading P per unit length of circumference, the maximum deflection and bending stress are denoted W_{max} and S_{max}, respectively. Graphs showing the variation of W_{max}/W and S_{max}/S with CR are plotted in *Fig.* 7 for a value of Poisson's ratio ν equal to 0.3. These graphs, practically coincident over the range of CR considered, are asymptotic to a line $CR = 2.05$ representing buckling of the plate. The maximum resultant stress in the plate is $(P/H) + S_{max}$.

EXAMPLES: The following problems illustrate how the graphs may be used. Data for a plate with edge clamped and with tensile radial load are as follows: radius $R = 15$ inches, thickness $H = 0.25$ inch, pressure $q = 4$ psi, tensile radial load $P = 800$ lb per inch, modulus of elasticity $E = 30{,}000{,}000$ psi, Poisson's ratio $\nu = 0.3$.

Flexural rigidity D is first calculated:

$$D = \frac{EH^3}{12(1-\nu^2)} = 42{,}930 \text{ lb-in.}$$

Hence

$$CR = R\sqrt{\frac{P}{D}} = 15\sqrt{\frac{800}{42{,}930}} = 2.05$$

Hence, from *Fig.* 6, for a tensile radial load,

$$\frac{W_{max}}{W} = 0.76 \text{ and } \frac{S_{max}}{S} = 0.86$$

Now

$$W = \frac{qR^4}{64D} = \frac{4(15)^4}{64(42{,}930)} = 0.0737\text{-in.}$$

$$S = 0.75\left(\frac{R}{H}\right)^2 = 0.75(4)\left(\frac{15}{0.25}\right)^2 = 10{,}800 \text{ psi}$$

Hence

$$W_{max} = 0.76(0.0737) = 0.056\text{-in.}$$

$$S_{max} = 0.86(10{,}800) = 9290 \text{ psi}$$

The maximum resultant stress occurs radially at the clamped edge and its magnitude is

$$\frac{P}{H} + S_{max} = 3200 + 9290 = 12{,}490 \text{ psi}$$

This stress is tensile. Since $W_{max}/H = 0.056/0.25 = 0.224$, the small-deflection theory is valid.

For a plate with edge simply supported, assume the same data as for plate with edge clamped except that pressure $q = 2$ psi. Values of flexural rigidity D and CR are the same as before. From *Fig.* 7, and for a tensile radial load,

$$\frac{W_{max}}{W} = \frac{S_{max}}{S} = 0.5$$

Now

$$W = \left(\frac{5+\nu}{1+\nu}\right)\frac{qR^4}{64D} = \frac{5.3(2)(15)^4}{1.3(42{,}930)(64)} = 0.150\text{-in.}$$

$$S = \frac{3(3+\nu)}{8} q \left(\frac{R}{H}\right)^2 = \frac{3(3.3)(2)}{8}\left(\frac{15}{0.25}\right)^2 = 8910 \text{ psi}$$

Hence

$$W_{max} = 0.5(0.150) = 0.075\text{-in.}$$

$$S_{max} = 0.5(8910) = 4455 \text{ psi}$$

The maximum resultant stress occurs at the center and its magnitude is

$$\frac{P}{H} + S_{max} = 3200 + 4455 = 7{,}655 \text{ psi}$$

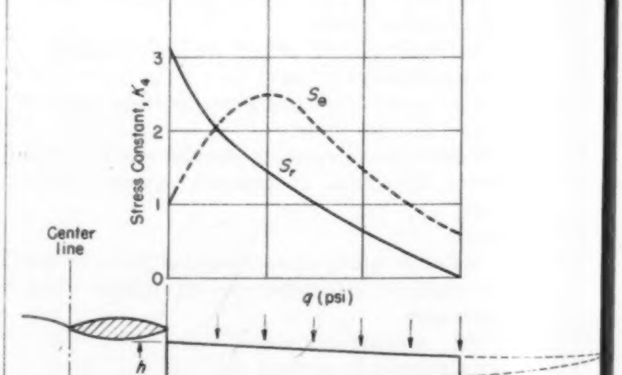
This stress is tensile. Since $W_{max}/H = 0.075/0.25 = 0.300$, the small deflection theory is valid.

Tapered Circular Plate: In a recent paper[3] it was shown that the problem of calculating the stresses in a circular plate tapering linearly towards its outer edge and bent by any axially symmetrical system of loading, may be solved if the value of Poisson's ratio for the material is assumed to be 1/3. This value of Poisson's ratio gives sufficiently accurate results for most cases of metallic plates.

This section presents data for two cases of plates in which the inner edge is clamped, the outer edge is free, and when the loading is uniformly distributed over the plate surface or uniformly distributed along the outer edge. Full details of the method of calculation for these and other cases are given in the paper previously mentioned.[3]

SURFACE LOADED: In *Fig.* 8 are shown the distributions of radial stress S_r and circumferential stress S_θ

Fig. 8—Loading conditions and typical stress-constant distribution curves for a special case of a tapered circular plate subjected to a uniformly distributed surface load



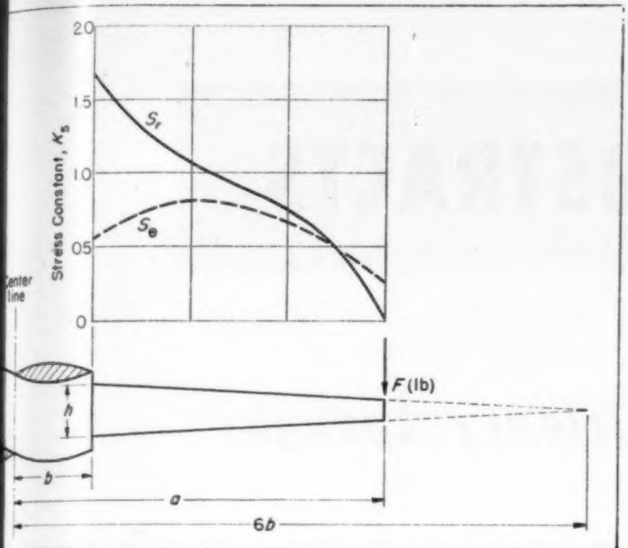


Fig. 9—Same case shown in *Fig.* 8 except that the load is uniformly distributed around the outer edge of the tapered circular plate

for a uniformly loaded plate with a specific taper and in which the outer radius a is four times the inner radius b. It will be seen from this figure that the maximum stress acts radially at the inner clamped edge. Calculations of the radial stress at this point have been made for three cases in which the ratio of the outer to the inner radius of the plate a/b, is 2, 3, or 4 and the results are given in TABLE 1. These maximum radial stresses are compared with those for corresponding plates having constant thickness and the percentage increases in the stresses due to the effect of the taper are also given in TABLE 1.

EDGE LOADED: In *Fig.* 9 are shown the distributions of radial stress S_r and circumferential stress S_θ for a plate carrying a load uniformly distributed around the outer edge and with the outer radius a four times the inner radius b. The maximum stress acts radially at the inner clamped edge. Calculations of the radial stress at this point have been made for the three cases in which the ratios of the outer to the inner radii, a/b, are 2, 3, and 4. Results for these cases and comparative data for constant thickness plates are given in TABLE 2.

EXAMPLE: A plate tapers linearly from a thickness of 1 inch at its inner clamped edge of 5-inch radius to a thickness of 0.4-inch at its outer free edge of 20-inch radius. Find the maximum stress induced by a uniformly distributed load of 10 psi. It

Table 1—Comparison for Distributed Load

Plate Proportions a/b	K_4 Tapered Plate	K_4 Const. Thick. Plate	Increase (per cent)
2	1.054	1.036	1.7
3	2.213	2.140	3.4
4	3.130	2.989	4.7

Table 2—Comparison for Edge Load

Plate Proportions a/b	K_5 Tapered Plate	K_5 Const. Thick. Plate	Increase (per cent)
2	0.763	0.748	2.0
3	1.285	1.195	7.5
4	1.717	1.501	14.4

will be observed that this plate has the same taper as that for which the data have been compiled. From TABLE 1,

$$S_{max} = K_4 \frac{qa^2}{h^2} = 3.130 \frac{10(20)^2}{1^2} = 12{,}520 \text{ psi}$$

Assume that the same plate is subjected to a total load of 10,000 lb uniformly distributed around the free edge of the plate. From TABLE 2,

$$S_{max} = K_5 \frac{F}{h^2} = 1.717 \frac{10{,}000}{1^2} = 17{,}170 \text{ psi}$$

REFERENCES

1. H. D. Conway—"Bending of Rectangular Plates Subjected to a Uniformly Distributed Lateral Load and to Tensile or Compressive Forces in the Plane of the Plate," *Journal of Applied Mechanics*, Vol. 16, No. 3, September, 1949, Pages 301-309.
2. Roberto Contini—Discussion, *Journal of Applied Mechanics*, Vol. 17, No. 1, March 1950, Pages 99-100.
3. H. D. Conway—"Axially Symmetrical Plates with Linearly Varying Thickness," *Journal of Applied Mechanics*, Vol. 18, No. 2, June, 1951, Pages 140-142.

DESIGN ABSTRACTS

Is Technical Proficiency Enough?

EVERY ENGINEER is interested in advancing his status. Sometimes this advancement requires an increase in technical proficiency. Sometimes it depends on other, more personal factors. Recently, the American Society for Engineering Education invited key men from industry and education to discuss the question, "What do we expect of an engineer?" The answers in the accompanying abstracts are varied and highly interesting

Design Engineering

By W. E. Johnson

General Manager
Nucleonics Department
General Electric Co.
Richland, Wash.

THE TERM Design Engineering is used with such completely different meanings that it is necessary for each author on the subject to define accurately what he means by this term. In this particular paper, the term Design Engineer is used to denote that field of activity in an organization which assumes the full responsibility for the design, development and quality control of a manufactured product. This definition excludes other engineering functions associated with the manufacturing and engineering industries, such as those of the application engineer, the sales engineer, field service engineers, manufacturing engineers and some others. It will be noted that this definition is much broader than that which places a man on the drafting board.

FUNCTIONS OF THE DESIGN ENGINEER: It is not feasible in any one paper to discuss fully the very wide range of functions that may be performed by the design engineer. For the purposes of this paper, it will be restricted to the functions of a design engineer in that part of industry which manufactures industrial apparatus and consumer products, such as appliances and automobiles. Recognizing the limitations of this discussion, the functions of the design engineer in certain segments of the manufacturing industry may be itemized as follows:

Creation and Development of New Products: Any manufacturer producing a product for sale is faced with the realization that ultimately his product may become obsolete and be replaced by some other device which will perform the same function at lower cost or perhaps perform a broader range of functions. He is also faced with the prospect of seasonal or variable demand for his product.

Here the function of the design engineer is quite clear. It is his job to conceive ideas for new products, to evaluate the discoveries of fundamental research and translate those discoveries into practical applications in new products. It is his job (with the help of market research analysts) to evaluate the economic worth of a proposed new product, to estimate its cost, its performance, its life, and to analyze the advantages that will accrue to the customer by its purchase.

As to the detailed functions to be performed, it is obvious that any individual may have a very narrow function or a very broad one. Depending upon the individual's aptitude and ability, he may have a very minor job in the drafting room, or he may be a highly technical man specializing on some one subject. On the other hand, the individual may be directing the entire engineering and drafting organization.

Preparation of Drawings and Specifications: While the preparation of drawings and specifications may in some cases be a distasteful chore without the apparent glamour of development work, it must be recognized that a factory cannot produce the product without detailed specifications.

The specification of materials, the metallurgical properties, and the final shape and surface conditions of those materials is the ultimate result of our engineering. The making of these drawings and the writing of specifications is only part of the story. When the job is properly done, it usually represents many, many hours of conferences with planners, factory specialists, tool designers, quality control experts, vendors, and others before the drawings and specifications represent a finished job that the factory can use.

• • •

. . . it is his job to conceive ideas, to evaluate discoveries and to translate them into practical applications

• • •

Control of Quality: It is fairly common practice to divorce the formal quality control function in the factory from the engineering division. As a matter of fact, practices in different manufacturing organizations vary quite widely. One fundamental, however, must be recognized: it is not possible to get more quality out of a product than has been designed into it in the first place. In this sense the design engineer performs the first and most important function in control of quality.

Design and Development of Tools: The term production tools or "engineering tools" includes the specialized

(*Continued on Page* 210)

NEW PARTS

AND MATERIALS

... presented in quick-reference data sheet form for the convenience of the reader. For additional information on these new developments, see Page 189

Graphited Bronze Bearings — 1

Bronze Bearings Inc., 544 North Ave. E., Cranford, N. J.

Designation: GOPI.

Style: Sleeve; graphite-impregnated.

Size: ¾ to 24 in. ID, 25 in. max OD; lengths to 24 in.

Service: Constant film of graphite lubrication; temperatures to 450 F.

Design: Cast bronze bearings with channels impregnated under pressure and heat with pure graphite and special binder; graphite impregnation on ends for thrust lubrication; style and size to specifications.

Application: Heavy static bearing loads; liquid-immersed bearings; high-temperature applications.

For more data circle MD 1, Page 189

Air Flow Switch — 2

Coral Designs Div., Henry G. Dietz Co., 12-16 Astoria Blvd., Long Island City 2, N. Y.

Designation: Cat. 113.

Style: Moving vane; snap-action switch.

Size: 2¾ in. long x 2 in. wide x 1½ in. high; ⅝-in. mounting stud extends 1⅜ in. from side of case.

Service: Actuates on air-flow failure when air pressure falls below set operating pressure down to 0.2-in. water (static) min; normally-open switch rated 5 amp, 250 v, a-c only; switch approved by UL.

Design: Stainless steel vane travels in duct; mounting stud contains air intake hole; most machine parts brass, cadmium-plated; sheet aluminum case.

Application: Guarding against air-flow failure in air-conditiong, refrigeration, and electronic tube forced-air cooling equipment.

For more data circle MD 2, Page 189

Fan Hub — 3

Lord Mfg. Co., Erie, Pa.

Style: Rubber sandwiched between mounting washer and hub.

Size: 1¾ in. diam x 1 in. long; 0.064-in. shaft diam; three 0.191-in. mounting holes.

Service: Isolating motor noise from fan blades; handles fans to 20 in. diam.

Design: Aluminum washer, riveted to fan blades, is bonded to neoprene flexing element of proper stiffness to insure fan stability and vibration isolation; neoprene element is bonded to zinc die-cast hub which attaches to motor shaft; socket-head set screw.

Application: Air conditioners, blowers.

For more data circle MD 3, Page 189

Reversing Gearmotor — 4

Acro Mfg. Co., Columbus 16, Ohio

Designation: Crise model AD.

Style: Package shaded-pole motor, gear train and controls.

Size: 5 in. high x 3$\frac{11}{16}$ in. wide x 1¾ in. deep; output shaft extension ½ in.

Service: Rotation at 2, 7½, or 27 rpm with torque to 10.0 lb-in.; built-in low-voltage control circuit starts, stops and reverses motion; internal stopping pins available to limit motion from 90 to 270 deg; motor can operate at continuous stall without burning out; adapters available for line-voltage conduit installations.

Design: Aluminum die-cast housing; tool-steel output shaft; lifetime-lubricated bearings.

For more data circle MD 4, Page 189

NEW PARTS AND MATERIALS

Variable-Speed Drive 5

Speed Selector Inc., 118 *Noble Ct., Cleveland* 13, *O.*

Designation: Countershaft drive.

Style: Assembly of countershaft stand, adjustable motor support and slide rods.

Size: Approximately 23⅝ in. long x 26¾ in. wide x 10¼ in. high.

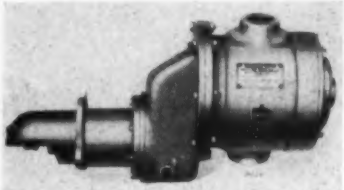
Service: Variable speed up to 8:1 ratio with assembly (3), below, 64:1 with assembly (4) below; 2 to 15 hp.

Design: Assembled in four ways—(1) sliding motor base, (2) sliding motor base with integral or pillow-block countershaft, (3) fixed motor base with "fixed-center" variable-pitch sheaves on countershaft and motor, (4) compound drive using four variable-pitch, fixed-center sheaves; used with 7 or 8-in. single or double-groove sheaves; motor frame size to NEMA 326; control mounted as desired, adaptable for remote; sealed ball-bearing countershaft.

For more data circle MD 5, Page 189

Air-Motor Starters 7

Ingersoll-Rand Co., 11 *Broadway, New York* 4, *N. Y.*



Designation: 9 BM, 20 BM.

Style: Package air motor and Bendix drive.

Size: 9 BM, approximately 17 in. long x 6 in. wide x 7 in. high, weight, 40 lb; 20 BM, approx. 23 in. long x 11½ in. high x 8¾ in. wide, weight, 103 lb.

Service: For starting diesel or gasoline engines up to 3500 cu in. piston displacement, using air or natural-gas pressures from 40 to 140 psi; 9 BM develops up to 16 hp, requires 7 cu ft air per start; 20 BM develops up to 41 hp, requires 16 cu ft per start; right or left-hand rotation.

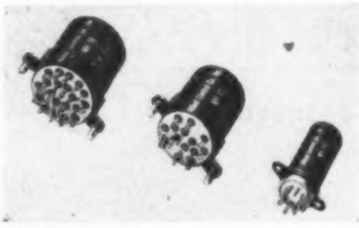
Design: Five-vane rotary air motor drives Bendix drive; air motor has hardened-steel rotor, hardened wear-resistant alloy cylinder, bronze end-plates; ball or roller bearings; Bendix housing can be rotated on gear case or gear case rotated on motor housing to clear engine projections.

Application: Engines used in lumbering, petroleum, mining, marine, heavy-construction and power fields.

For more data circle MD 7, Page 189

Subminiature Relays 6

Allied Control Co. Inc., 2 *East End Ave., New York* 21, *N. Y.*



Designation: MHB, MHA.

Style: Hermetically sealed; 2, 4, 6-pole, double-throw.

Size: 6-pole, 1 3/16 in. diam; 4-pole, 1 1/32 in.; 2-pole, ⅝-in.; seated height, 1½ in.

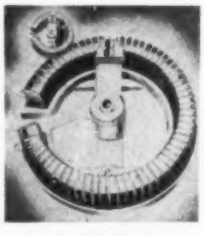
Service Operating-temperature range—MHB, −55 to +85 C, MHA, −65 to +200 C; withstand vibration of 10g, shock of 30g of 10 millisec duration; hermetically sealed for operation to 70,000 ft altitude; coil voltage, 26.5 v d-c; coils will withstand overvoltage of 23% for 8 hr; will operate at 18 v d-c, release at 13 v d-c after exposure to limiting conditions of voltage or temperature stated above; power, less than 1 w; contacts rated 2 amp noninductive at 28 v d-c; life expectancy, over 1 million operations; contact-circuit resistance, less than 0.2-ohm; meet requirements of USAF Spec. MIL-R-5757.

Application: Aircraft, airborne equipment.

For more data circle MD 6, Page 189

Power Rheostats 8

P. R. Mallory & Co. Inc., 3029 *E. Washington St., Indianapolis* 6, *Ind.*



Style: Round; ribbon-wire wound.

Size and Service: 50-w, 75-w, 100-w, 150-w models have 32 sizes ranging 0.5 to 10,000 ohm total resistance; 225-w, 300-w, 500-w models have 25 sizes, 1 to 2500 ohm total resistance; ¼-in. diam shaft; ¾-32 externally threaded mounting bushing with 9/16 x 3/32-in. hex nut;

Model (watts)	Max. Current (amp) (smallest, largest size)	Steps (smallest, largest)	OD (in.)	Rotation (deg)
50	10.00-0.07	25-680	2 13/32	300
75	12.20-0.09	26-660	2¾	300
100	14.20-0.10	30-840	3⅛	300
150	17.30-0.12	28-1050	4 1/32	305
225	15.00-0.30	52-660	5 1/16	310
300	17.30-0.35	48-775	6 1/16	315
500	22.40-0.45	73-975	8	325

Design: Vitreous enamel core; hinged spring-loaded contact arm.

For more data circle MD 8, Page 189

JOHNSON BRONZE

SLEEVE BEARING DATA

Bearing DESIGN

JOHNSON BRONZE

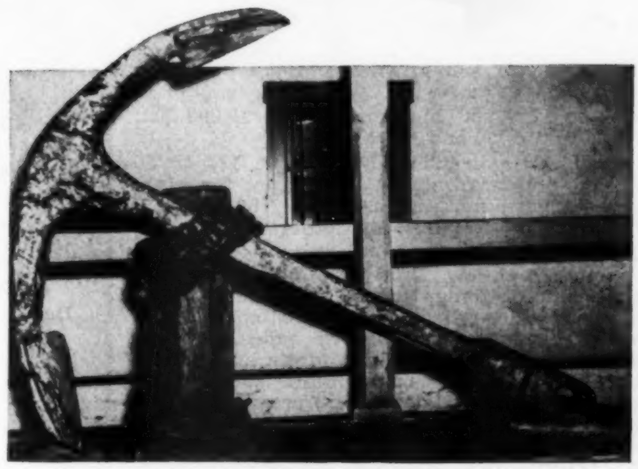
SLEEVE BEARING DATA

Corrosion of Bearings-1

ALL bearing materials should be fabricated to meet requirements of corrosion resistance. These requirements are of two distinct types. Corrosion resistance prior to installation and corrosion resistance after installation.

Prior to installation, bearings may corrode during shipment or in storage. The corroding medium usually is water or water vapor due to occasional exposure to high humidity or actual condensation of water where cold metal is brought into a warm room under such conditions that the temperature of the metal is below the dew point. In some rare cases corrosion may be caused by certain gases present in the atmosphere. These instances should be given individual study in order to arrive at the proper preventive. The resistance of the bearing metals to corrosion due to water or prior to installation is of a different order than corrosion resistance under operating conditions. In this first treatise we will limit the discussion to the former.

The approximate tendency to corrode in the presence of water is shown in figure No. 1, under room temperature conditions. Steel is the most sensitive of all the materials used and precautions have to be taken to protect the steel against rusting. The amount of protection required depends on the expected time of exposure to atmospheric conditions. If steel-backed bearings are to be placed in service shortly after manufacture, then a light film of oil will suffice. For periods of protection up to six months an electro-deposit of tin or a heavier oil coating is used. For periods of protection up to two years an electro-deposit of tin, plus a light grease is used. For longer periods or for overseas shipment a heavy grease is often used.



An excellent example of resistance to corrosion is this old bronze anchor recently dredged up from Monterey Bay, California, where it had lain in *salt water* for over 300 years

A protective oil is required for lead-base babbitt for storage periods longer than six months.

Both steel and lead-base babbitt are characterized by pitting when corrosion due to water vapor takes place. A few pits will not harm either of these materials but extensive corrosion may result in undesirable dimensional changes.

Copper-lead will corrode because the lead phase is exposed but the lead is isolated in small areas and not subject to the more extensive attack of lead-base babbitt.

Tin base babbitt, bronze and aluminum may stain on exposure to the atmosphere but damage due to corrosion under these conditions is practically unknown.

The corrosion of bearings under service conditions is due to entirely different factors than under storage conditions.

Service conditions are discussed in data sheet . . . Corrosion-2.

Engineering Service

Johnson Bronze offers manufacturers of all types of equipment a complete engineering and metallurgical service. We can help you determine the exact type of bearing that will give you the greatest amount of service for the longest period of time. We can show you how to design your bearings so that they can be produced in the most economical manner. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts free from prejudice. Why not take full advantage of this free service?

Relative Comparison of Corrosion

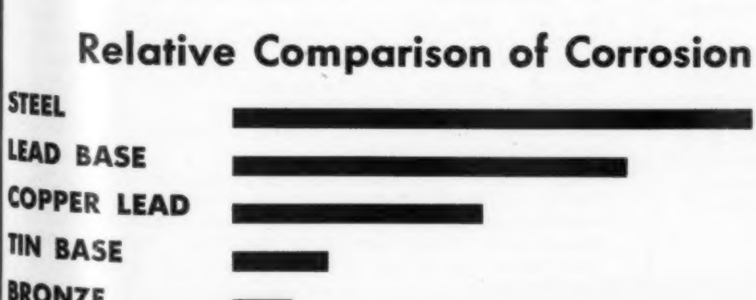


Fig. 1 Tendency of bearing material to corrode in the presence of water vapor at room temperature.

This bearing sheet data is but one of a series. You can get the complete set by writing to—

Johnson Bronze

SLEEVE BEARING HEADQUARTERS
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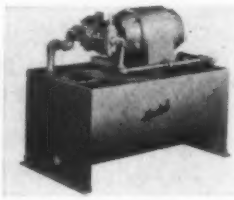
NEW PARTS AND MATERIALS

Hydraulic Power Units — 9

Haskel Engineering & Supply Co., 721 W. Broadway, Glendale 4, Calif.



Style: Package motor, pump and reservoir tank.

Size: 20, 40, 60, 100, 120, 150-gal tanks; low-pressure units to 1750 psi; high-pressure to 10,000 psi; high-low units to 1750 and 10,000 psi.

Service: Supplying hydraulic power oil at 1½ to 50 gpm for low-pressure unit, 1½ to 5 gpm for high-pressure; standard motors, 220/440 v, 60-cycle, 3-phase, splashproof, 1.5 to 40 hp; others special.

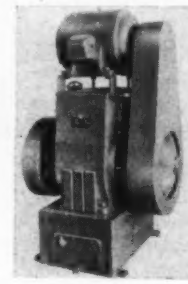
Design: Single-pump (high or low-pressure units) or double-pump (high-low units); pumps integrally mounted on motor flange up to 15 hp; units have adjustable pressure-relief valves, piston or dial-type pressure gages, visible oil-level indicator plugs, filtered-vent filler caps, double drain ports, adjustable unloading valves on high-low models; double pumps available on low or high-pressure models to supply 100 or 10 gpm, respectively; 12 ft hydraulic hose with quick-disconnect couplings on pressure and return lines, dial-type temperature gage, towing tongue and casters, all special.

Application: Hydraulic presses, machines.

For more data circle MD 9, Page 189

High-Vacuum Pump — 11

F. J. Stokes Machine Co., Philadelphia 20, Pa.



Designation: Microvac model 812-F.

Style: Package piston pump and motor.

Size: 38 in. long x 36 in. wide x 76 in. high; weight 2400 lb.

Service: Exhausting air at 500 cfm; suitable for vacuum processing work; can discharge slugs of liquid without injury; automatic lubricating oil flow; oil settles in reservoir when vacuum broken.

Design: Driven at 390 rpm by 25-hp motor; water-cooled.

For more data circle MD 11, Page 189

Nonreversing Starter — 10

Euclid Electric & Mfg. Co., Madison, O.

Designation: Bulletin 5301.

Style: Magnetic across-the-line with manual disconnect switch.

Size: 0, 1, 2 sizes—24$\frac{5}{16}$ in. high x 9⅞ in. wide x 6⅝ in. deep; size 3—31¾ in. high x 15¾ in. wide x 10 in. deep; size 4—special.

Service: Starting 25 to 60-cycle squirrel-cage motors or as primary switches on wound-rotor induction motors; low-voltage and overload protection with 3-wire pushbutton controls, low-voltage release with 2-wire pilot circuit device (both special); short-circuit protection with fused disconnect switch; inverse time-limit overload protection with thermal overload relays.

Design: Mill or line type copper contacts, self wiping; graphite-bronze self-lubricated bearings; stainless steel contact springs; flexible braided-copper shunts; 3-pole fused or unfused manual disconnect switch interlocked with door; snap-action bimetallic-disk thermal overload relays, melting-alloy type on sizes 3 and 4; double-break silver auxiliary contacts, bridging type; magnetic blowout, all except size 0; welded stamped-steel frame.

For more data circle MD 10, Page 189

Electric Steam Boiler — 12

Livingstone Engineering Co., 100 Grove St., Worcester 5, Mass.

Designation: Speedylectric Series 1½.

Style: Adjustable pressure; electrode-operated.

Size: 22-in. long x 14-in. wide x 28-in. high.

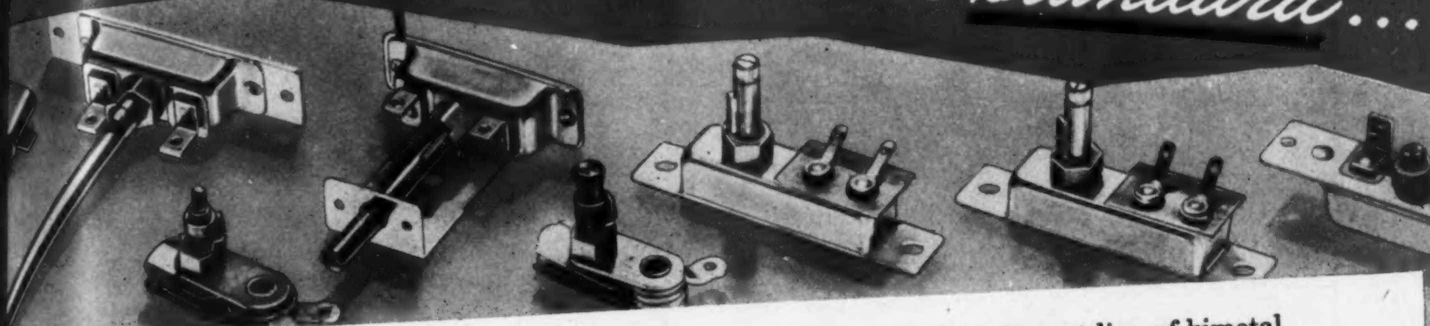
Service: Models for 5 pressure ranges—15, 50, 100, 200 and 250 psi max; average operation on 220 v delivers 45 lb of steam per hr (50,000 Btu per hr); available for 220, 440, 550 v single-phase, requiring 15 kw power input; pressures adjustable, with current consumption automatically adjusted to maintain steam output, pressure and temperature; listed by Underwriters Laboratories; 50 psi model is ASME code boiler carrying National Board Stamping and Insurance Company Certificate

Design: Heat generated by electrical resistance of boiler water to flow of current between solid metal electrodes; accessory water feeders available where continuous boiler operation required; current, flow and power input stop if boiler runs out of water.

Application: Open or closed steam systems.

For more data circle MD 12, Page 189

the *special* thermostat you need may be a Stevens *standard*...



● The Stevens thermostats listed are just a few from the largest line of bimetal thermostats in the industry. So even if you have an unusual problem in thermostat design, check with Stevens first. Chances are a *standard* Stevens thermostat will satisfy all your performance, size, cost and delivery problems.

A-4143

FEATURES	TYPE S	TYPE SA	TYPE R	TYPE W	TYPE M	TYPE C
STYLES						
Non-Adjustable	Yes	Yes	Yes	Yes	Yes	Yes
Adjustable	Yes	Yes	Yes	Yes	No	No
Manual Reset	No	Yes	No	No	No	No
Single Pole Double Throw	Yes	Yes	No	No	No	No
Positive Acting	Yes	—	Yes	—	—	Yes
Snap Acting	No	Yes	No	Yes	Yes	No
Open	Yes	Yes	No	No	Yes	Yes
Enclosed	No	No	Yes	Yes	Yes	Yes
Hermetically Sealed	Yes	Yes	Yes	Yes	Yes	Yes
ADJUSTABLE TEMPERATURE RANGE, Maximum	650° F.	650° F.	650° F.	650° F.	—	—
OPERATING TEMPERATURE, Maximum	650° F.	650° F.	650° F.	650° F.	650° F.	400° F.
DIFFERENTIAL, as measured on bimetal						
Maximum	App. 15° F.	150° F.	App. 15° F.	50° F.	600° F.	App. 5° F.
Minimum	App. 5° F.	10° F.	App. 5° F.	5° F.	8° F.	App. 5° F.
RATING (Non-Inductive Load)						
115 Volts a.c.	15 amps.	25 amps.	15 amps.	12 amps.	8 amps.	5 amps.
230 Volts a.c.	10 amps.	15 amps.	10 amps.	8 amps.	4 amps.	2 amps.
28 Volts d.c.	15 amps.	25 amps.	15 amps.	12 amps.	10 amps.*	5 amps.
ANGLE OF ROTATION, Maximum	300°	300°	300°	300°	—	—
MOUNTING	Single Stud	Single Stud	See Bulletin F-2003	See Bulletin L-4079	See Bulletin F-2009	See Bulletin F-2008
VIBRATION RESISTANCE	Fair	Good	Fair	Good	Good	Good
CORROSION RESISTANCE						
Standard	Good	Good	Good	Good	Good	Good
Hermetically Sealed	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
HIGH ALTITUDE PERFORMANCE	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
SIZE	See Bulletin F-2006	See Bulletin L-4144	See Bulletin F-2003	See Bulletin L-4079	See Bulletin F-2009	See Bulletin F-2008

*Will interrupt 150 amps. 12 volts d.c.

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MANSFIELD, OHIO

NEW PARTS AND MATERIALS

Neoprene-Fabric Packings 13

Periflex Inc., Hazel Park, Mich.

Style: Cup, U and flange taper lip, and O-ring.

Size: Cup, ⅜ to 28 in. OD; U-type, flat bottom, 9/16 to 29¾ in. OD, 3/16 to 28 in. ID; U-type, round bottom, 1⅜ to 8 9/16 in. OD, ¾ to 7 in. ID; flange, 11/16 to 12 in. OD, ¼ to 9½ ID; O-ring type, sizes 1 through 88 on Army-Navy drawing AN6227, sizes 1 through 52 on AN6230.

Service: Sealing under pressures from 0 to 10,000 psi depending on installation; temperatures, −65 to +300 F; neoprene-fabric compound withstands oils, acids, bases, salt solutions, alcohol.

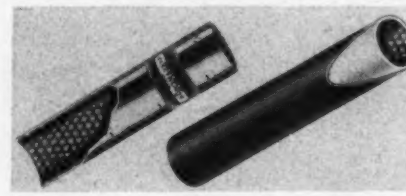
Design: No. 100 molding compound gives flexible sealing lip for positive seal at low pressures; No. 300, with No. 10 duck insertion, for heavy-duty service; tapered lip provides interference for positive seal, avoids friction and extrusion.

Application: Cylinders, presses, pumps, valves.

For more data circle MD 13, Page 189

Coated Electrical Tubing 15

Steel and Tubes Div., Republic Steel Corp., 224 *East* 131*st St., Cleveland* 8, *O.*



Designation: Electrunite, Dekoron-coated.

Style: Plastic-coated rigid tubing.

Size: ½, ¾, 1, 1¼, 1½, 2-in. OD standard; 2½-in. OD special.

Service: Wiring raceways in corrosive atmospheres; polyethylene coating resists all common acids, alkalies and solvents except chlorinated hydrocarbons, aromatic and aliphatic hydrocarbons; withstands long exposure to gasoline and hydrocarbon oils; coating has dielectric strength of 460 v per mil, volume resistivity—10^{15} ohm per cm, dielectric constant—2.3, power factor—0.0005.

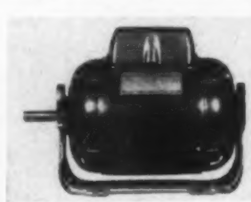
Design: Galvanized tubing coated with 0.20-in. black polyethylene; standard tube fittings, double-wrapped with polyethylene or vinyl-backed tape, used for connection; tubing bent with special tool.

Application: Machinery in chemical, packing industries.

For more data circle MD 15, Page 189

Resilient-Base Motor 14

Small and Medium Motor Divs., General Electric Co., Schenectady 5, *N. Y.*



Designation: Tri-Clad, type KCS, resilient-base.

Style: Capacitor; single-phase induction.

Designation: Tri-Clad, type KCS, resilient-base.

Style: Capacitor; single-phase induction.

Size and Service: For 115/230 v, 60 cycles, single-phase operation except 5 hp for 230 v only; resilient base construction isolates torque pulsation and vibration;

Size (hp)	Speed (sync., rpm)	Frame Size (NEMA)	Current (amp at 230 v)	Torque (full load, lb-ft)
½	900	224	[1]	[1]
¾	12000	204	6.1	3.46
	900	225	[1]	[1]
1	1800[2]	203	7.2	3.07
	1200	224	7.6	4.62
1½	3600	203	8.7	2.3
	1800	204	9.7	4.6
	1200	225	10.8	6.92
2	3600	204	11.0	3.07
	1800[2]	224	11.9	6.14
3	3600	224	16.3	4.6
	1800	225	17.3	9.2
5	3600	225	26.5	7.66

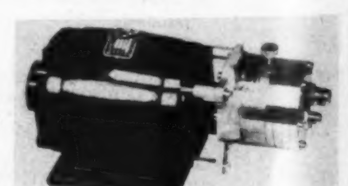
[1] Data not available. [2] available with automatic-reset thermal overload protection.

Design: Open, dripproof cast-iron motor construction; built-in transfer switch; prelubricated ball bearings; dynamically balanced.

For more data circle MD 14, Page 189

Metering Pump 16

Mechanical Products Corp., 168 *N. Ogden Ave., Chicago* 7, *Ill.*



Designation: VQDC.

Style: Package positive-displacement pump and drive.

Size and Service: Deliver nonpulsating, controlled volume of liquid in small capacities; corrosion and acid-resistant; noncontaminating; for 115 v, 60 cycle, a-c operation;

Type	Capacity (cc per sec, water)	Size (length x width x height, in.)
5520-EM	0 to 25, adjustable	18 x 8 x 6½
132-W	4 to 30, adjustable	11½ x 4 x 5½
2412	10 to 75, fixed*	12½ x 4¼ x 5½

* See note under "Design".

Design: Stainless-steel pump; type 5520-EM has variable-speed transmission, ⅛-hp motor; type 132-W, governor-controlled variable-speed motor, 1/25-hp; type 2412 uses speed reducer with ½-hp motor, can be throttled to 2 cc per sec by restricting discharge, down to 0 cc per sec by using restricted bypass to intake; flared-tube or rubber-tube inlet and outlet fittings; pump heads demountable and interchangeable.

Application: Pumping chemical solutions, radioactive liquids, soaps, oils, liquid fats, grease, wax, glue, other hot, cold, viscous or nonviscous liquids.

For more data circle MD 16, Page 189

NEW PARTS AND MATERIALS

Self-Locking Retainer 17

Waldes Kohinoor Inc., 47-16 *Austel Place, Long Island City* 1, *N. Y.*

Designation: Truarc Series 5300.

Style: Single-thread; dished body.

Size:

Thread (American Standard)	Length (in.)	Height (in.)	Clearance Diam (in.)
6-32	0.434	0.376	0.462
8-32	0.481	0.416	0.504
10-24	0.538	0.467	0.560
10-32	0.538	0.467	0.560
¼-20	0.677	0.587	0.710
¼-28	0.677	0.587	0.710

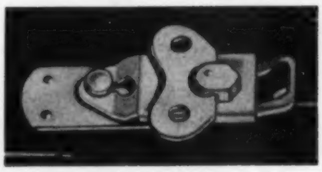
Service: Self-locking; equal load distribution against part being held; separate washer not needed.

Design: Drawn helical segment with tapered inner edge forming a single thread; engagement approximately 300 deg; dished triangular body flattens under torque.

For more data circle MD 17, Page 189

Locking Latch 19

Simmons Fastener Corp., Albany 1, *N. Y.*



Designation: Link-Lock.

Style: Mechanical; springless; wing-nut operated.

Size: 5 in. long x 1½ in. wide.

Service: Positive locking with 450-lb pulldown pressure, 1000-lb tension loading; withstands −70 F temperature; pulldown pressure can be used for gasket sealing.

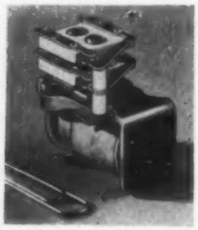
Design: Vertical-moving latch is attached through pin to disk rotated by wing nut; pin is offset from center so that 180-deg rotation flips lock open or shut; heat-treated alloy-steel construction; engagement latch detail can be varied; bolt or screwhead can be used instead of wing nut.

Application: Watertight sealing with gasket.

For more data circle MD 19, Page 189

Midget Relay 18

R-B-M Div., Essex Wire Corp., Logansport, Ind.



Designation: SM-RF.

Style: Single or double-pole, normally-open or closed; single-pole, double-throw.

Size: $1\frac{1}{8}$ in. long x ¾ in. wide; height—SPNO, $\frac{61}{64}$-in., DPNO, $1\frac{3}{64}$ in., SPDT, $1\frac{11}{64}$ in.; weight, 1 oz.

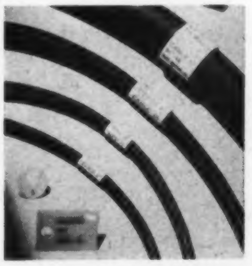
Service: Low maximum capacitance between contacts and ground of 2.5 mmf; ratings (for DPNO, 28-v d-c relay), 32 v d-c max. operating voltage, 26.5 v d-c nominal coil voltage, 3 amp contact ratings for 32 v dc or 115 v a-c noninductive, 480 ± 10% ohm coil resistance (20 C) with current, 0.055 amp; vibration, 10g; pull-in power, approximately 0.48-w.

Design: Palladium contacts; ceramic stack insulators; available up to 4-pole, double-throw in standard contact arrangement.

For more data circle MD 18, Page 189

Wire and Cable Markers 20

Actioncraft Products, 8 *Sagamore Hill Dr., Port Washington, N. Y.*



Style: Rigid laminate; flat or sleeve.

Size: To specifications; sleeve markers, $\frac{1}{16}$ to 3-in. diam.

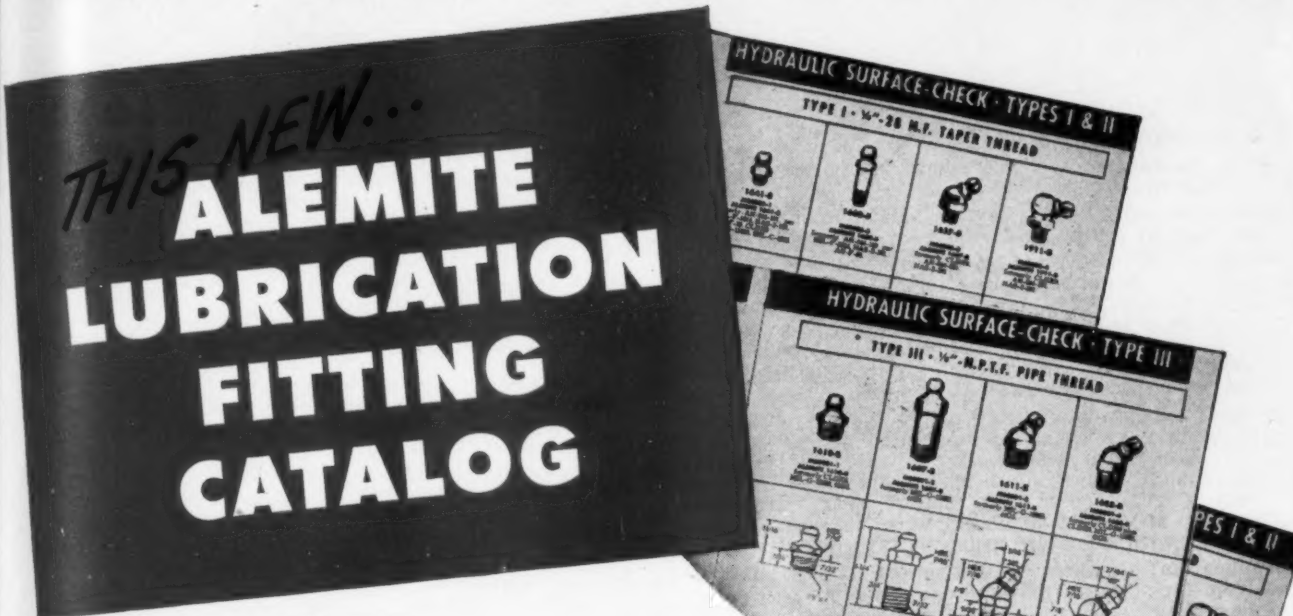
Service: Overlay of clear Vinylite plastic protects printed identification or color banding; resist abrasion, water, oil, gasoline, alcohol and most acids; fungus and vermin-proof.

Design: Vinylite plastic rigid sheet overlayed with clear plastic; can be punched with holes of desired shape; special tools for slipping sleeve markers over wire, and for looping cord through holes in flat markers available.

For more data circle MD 20, Page 189

Important!

to everyone designing and making equipment for the armed forces



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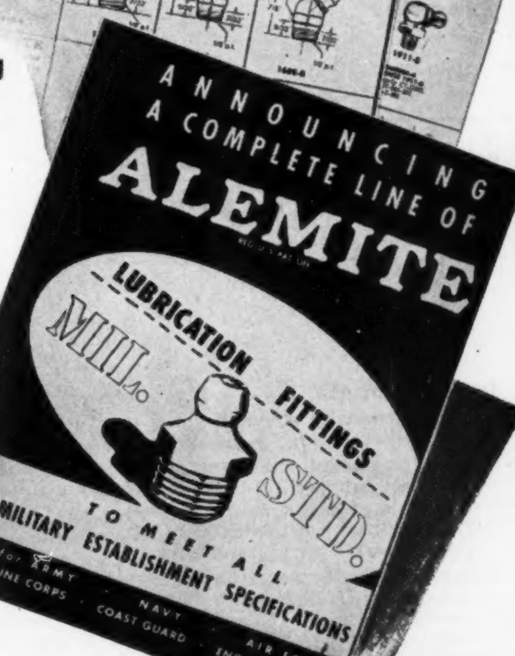

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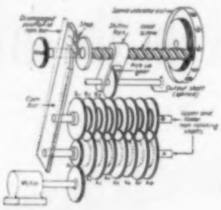
NEW PARTS AND MATERIALS

Multispeed Instrument Drive 21

Gorrell & Gorrell, Haworth, N. J.



Designation: M-M, S-M units.

Style: Package motor, gear train and speed-selection mechanism.

Size: S-M unit, 4¼ in. square x 6¼ in. high; M-M unit, 3¾ in. square x 5 in. high.

Service: S-M unit provides 20 oz-in. torque with rotation of output shaft in 1, 5, 15 sec, 1, 5, 15 min, 1, 4, 12 hr, 1, 2½ days, 1 or 4 weeks; M-M unit provides 5 oz-in. torque at same speeds except 1, 5 and 15-sec; for 115 v, 60 cycles, a-c; specials for adjacent speed ratios from 5:1 to 1:5, with individual ratio differences as small as 59/61.

Design: Synchronous motor drives machine-cut brass gears in gear train, each mounted on oilless bearing; knob turns lead screw, shifting a fork carrying pickup gear to mesh with proper gear in train; pickup gear, splined to output shaft, transmits power; M-M unit available with 30 oz-in. torque output, with same dimensions as S-M unit.

Application: Apparatus, instrument drives; disk or drum-type chart movements; time and sequence control.

For more data circle MD 21, Page 189

Pilot-Controlled Valve 22

Automatic Switch Co., 379-D Lakeside Ave., Orange, N. J.

Designation: ASCO.

Style: Three-way solenoid-valve operated.

Size: 12¾ in. high x 4½ in. long x 5 15/16 in. wide except 250-lb pressure models, 13¼ in. high; with 2-in. pipe, 16 in. high x 5⅛ in. long x 6⅝ in. wide except 250-lb pressure model, 16½ in. high; pipe sizes 1, 1¼, 1½ and 2 in.

Service: For alternately applying and exhausting pressure in controlled cycles; handles air, gas, oil or noncorrosive fluid; 125 or 250 lb max pressure, 10 lb min except 2-in. pipe models, 20 lb min; fluid temperature to 180 F; standard solenoids for 115 or 230 v, d-c or 25, 30, 50 or 60 cycle a-c.

Design: Screwed bronze main valve actuated by external piston automatically controlled by 3-way solenoid pilot valve; exhaust port closed, pressure applied to delivery port when solenoid energized; pressure supply cut off and delivery port connected to exhaust when de-energized; bronze seats; packless; composition disks in fully-shrouded bronze holders.

Application: Operation of diaphragm motor valves, air or hydraulic cylinders.

For more data circle MD 22, Page 189

Adjustable Door Fastener 23

Southco Div., South Chester Corp., 1400 *Finance Bldg., Philadelphia* 2, *Pa.*

Designation: Part number 14-10.

Style: Adjustable spring-retained pawl.

Size:

Size Number† (1)	Size Number† (2)	Grip (Min. in.)	Size* (max, in.)
11-11	11-12	⅜	⅝
12-11	12-12	9/16	15/16
13-11	13-12	13/16	1¼
14-11	14-12	1⅛	1½

†(1) cadmium-plated knob and screw. (2) chrome-plated knob and screw.

*Add ⅜-in. for spacer on flush-head models.

Service: Adjustable pawl-contact distance; grip can be tightened to form dust seal against gasket; resists heavy vibration.

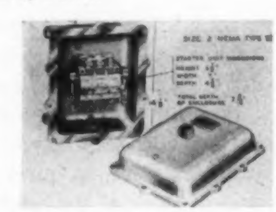
Design: Spring-retained pawl tightened by turning protruding knurled knob or flush screwdriver-operated head; installed with 2 rivets; no striker plate needed; delivered as single unit.

Application: Doors, panels, plates on motors, production machines, testing machines, commercial vehicles, airplanes.

For more data circle MD 23, Page 189

Explosion-Proof Starter 24

Arrow-Hart & Hegeman Electric Co., 103 *Hawthorn St., Hartford* 6, *Conn.*



Designation: Explo-Safe.

Style: Magnetic across-the-line, reversing or 2-speed.

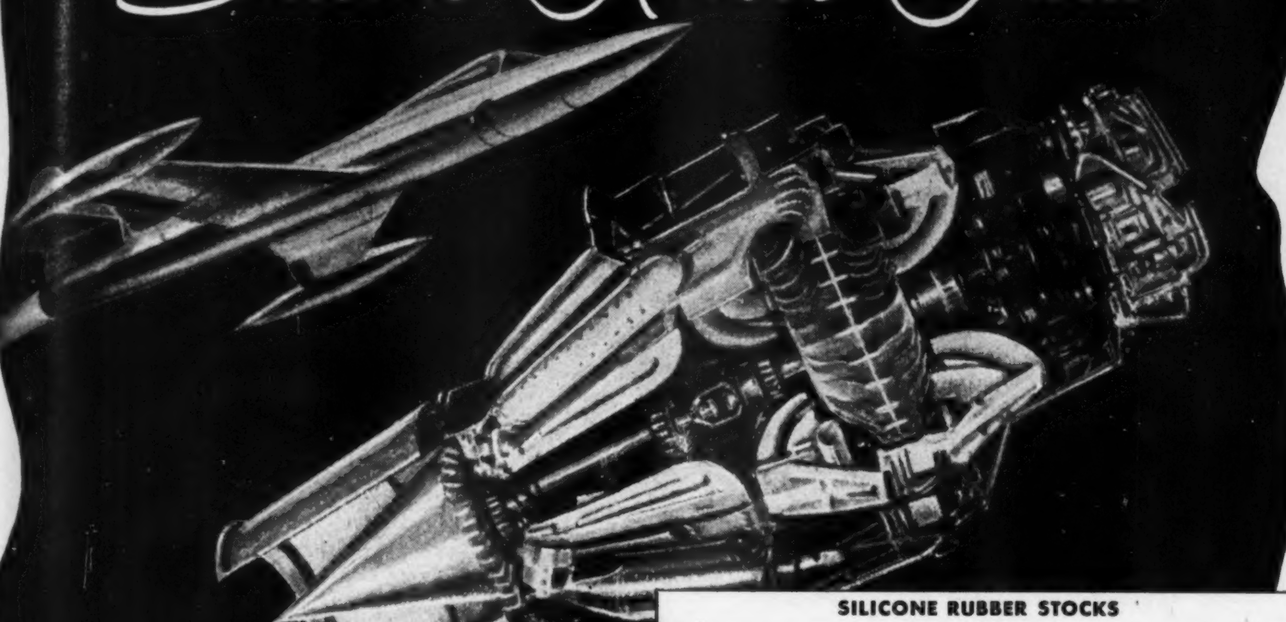
Size: NEMA sizes 0, 1, 2, 3, and 4 in all types.

Service: NEMA type VII, IX and IV enclosures, approved by UL for class I, group D (explosive gas and vapors), class II, groups E, F, and G (explosive dust, flyings and fibers), and weatherproof service, respectively; available for across-the-line, reversing, 2-speed separate-winding, or 2-speed consequent-pole (1 winding) starting; 1, 2, or 3-phase, 3 or 4-wire, 2 to 5 poles.

Design: Vertical-action magnet with knee-action fulcrum to transfer motion to horizontal contact plane and multiply leverage; alkyd plastic arc and track-resistant hood and base enclose operating mechanism; tongue-and-groove design arcing chambers with special baffle plates for size 4 starters for 50 and 100-hp motors; bimetallic, snap-action thermal overload relays, manual or automatic reset, with silver butt-type contacts; straight-through front wiring.

For more data circle MD 24, Page 189

Silicone Rubber Parts



COMPOUND NUMBER	HARDNESS Shore A Scale	TENSILE STRENGTH (p.s.i.) Avg.	TENSILE STRENGTH (p.s.i.) Min.	ELONGATION per cent Avg.	ELONGATION per cent Min.	TEMPERATURE RANGE (°F.) Low	TEMPERATURE RANGE (°F.) High	COMPRESSION SET % at 302° F.	DIELECTRIC STRENGTH volts/mil	COLOR After Curing
*Silastic 150	45 to 55	360	>250	250	>200	<−70	+500	40 to 60	500	White
160	55 to 65	490	>400	180	>150	<−70	+500	50 to 70	500	White
180	75 to 85	700	>575	85	>60	−90	+500	70 to 90	650	White
181	75 to 85	670	>550	85	>60	−80	+500	60 to 90	800	Gray
6-181	75 to 85	680	>500	65	>50	<−110	+500	40 to 60	800	Gray
250	40 to 55	650	>550	300	>250	<−110	+500	40 to 60	800	Orange-tan
**G-E 81223	40+5		800		400	−85	+520	65 to 75	480	†
**G-E 81271	50−5		800		250	−85	+520	65 to 75		†

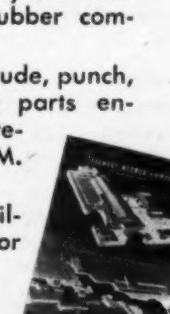
*Registered Trade-Mark of the Dow Corning Corporation.
**Specifications listed for this stock are based on cure of 24 hrs./480° F
†General Electric silicone rubber can be tinted in a choice of colors.

FOR EXTREME HIGH AND LOW TEMPERATURE APPLICATIONS

ONLY SILICONE rubber parts withstand the severe temperature conditions encountered in whistling, speeding, supersonic jets. These same SILICONE rubber compounds are available for application in transformers, aircraft and marine instruments, internal combustion engines, motors, and generators as well as chemical and electrical equipment.

ONLY SILICONE rubber parts retain their desirable physical, chemical and dielectrical properties within a temperature range of —110° to +500° Fahrenheit. These parts feature excellent resistance to weathering, oxidation, ozone and many chemicals. SILICONE parts advantageously replace many special metal constructions forced upon design engineers by the limited thermal stability of organic rubber compounds.

STALWART is prepared to mold, extrude, punch, and lathe-cut precision SILICONE parts engineered to meet individual requirements as well as S.A.E. and A.S.T.M. specifications.



Write today for the new 16-page, illustrated catalog Number 51SR-1 for additional details.

154-SR

STALWART RUBBER COMPANY

9180 NORTHFIELD ROAD • BEDFORD, OHIO

NEW PARTS AND MATERIALS

High-Temperature Paint 25

Speco Inc., 7308 Associate Ave., Cleveland 9, Ohio

Designation: M Aluminum.

Form: Liquid; available in 1 and 5-gal pails, 55-gal drums.

Service: Interior and exterior use at 200 to 700 F temperatures; resists fumes, moisture, mild acids, alkalies; coverage, estimated 550 sq ft per gal; brush or spray application.

Properties: Aluminum metallic pigment; sets in 3 hr, dries in 18.

For more data circle MD 25, Page 189

Synthetic O-Rings 26

Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio

Designation: Compound 41.

Style: Toroidal rings.

Size: 88 standard O-ring sizes from 1/16 to ¼-in. width, ¼ to 16 in. OD, specials to 4 ft OD.

Service: Sealing in temperature range, −65 to +300 F; resists aircraft-engine oils AN-VVO-446 grade 1120, AN-O-8, SAE 40, 50, 60 oils and similar fluids; Shore A hardness, 65 deg; elongation, 35%; tensile strength, 2135 psi.

For more data circle MD 26, Page 189

Heat-Resistant Alloy 27

International Nickel Co., 67 Wall St., New York 5, N. Y.

Designation: Incoloy.

Form: Sheet, strip, rod, wire, tubing.

Service: High-temperature and corrosive conditions; developed as low-nickel content replacement for Inconel, and has similar tensile properties, hardness, and rate of work hardening; can be welded with Inconel electrode.

Properties: Contains 32-36% nickel, 19-22% chromium, 0.10% carbon max, 1.50% manganese max, 0.03% sulphur max, 1.00% silicon max, 0.50% copper max, remainder iron; resists attack by sulphidation, green-rot, molten cyanide salts, oxidation, fused neutral salts.

For more data circle MD 27, Page 189

Electrical Tape 28

B. F. Goodrich Co., Akron, Ohio

Style: Adhesive.

Size: Roll, 60 ft long x ¾-in. wide; 0.007-in. thick.

Service: Electric insulation with dielectric strength, 8000 v; waterproof, abrasion-resistant; flameproof; resists acids, oil, alkalies and corrosive salts; adhesive is nontransferring.

Design: Koroseal material; packed in metal container, 12 to carton.

For more data circle MD 28, Page 189

Antirust Paint 29

Paint Corp. of America, Fidelity Bldg., Cleveland 14, Ohio

Designation: PCA-100, -101.

Form: Liquid; available in 1 and 5-gal cans, 55-gal drums.

Service: Preventing rust on new metal, stopping rust action on presently rusted metal; can be brushed or sprayed without extensive surface preparation; PCA-100 is black finish coat, 101 is clear base coat which can be painted over.

Properties: Penetrates through rust layer and seals surface.

For more data circle MD 29, Page 189

Chromate Coating 30

Enthone, Inc., Dept. MD, 442 Elm St., New Haven, Conn.

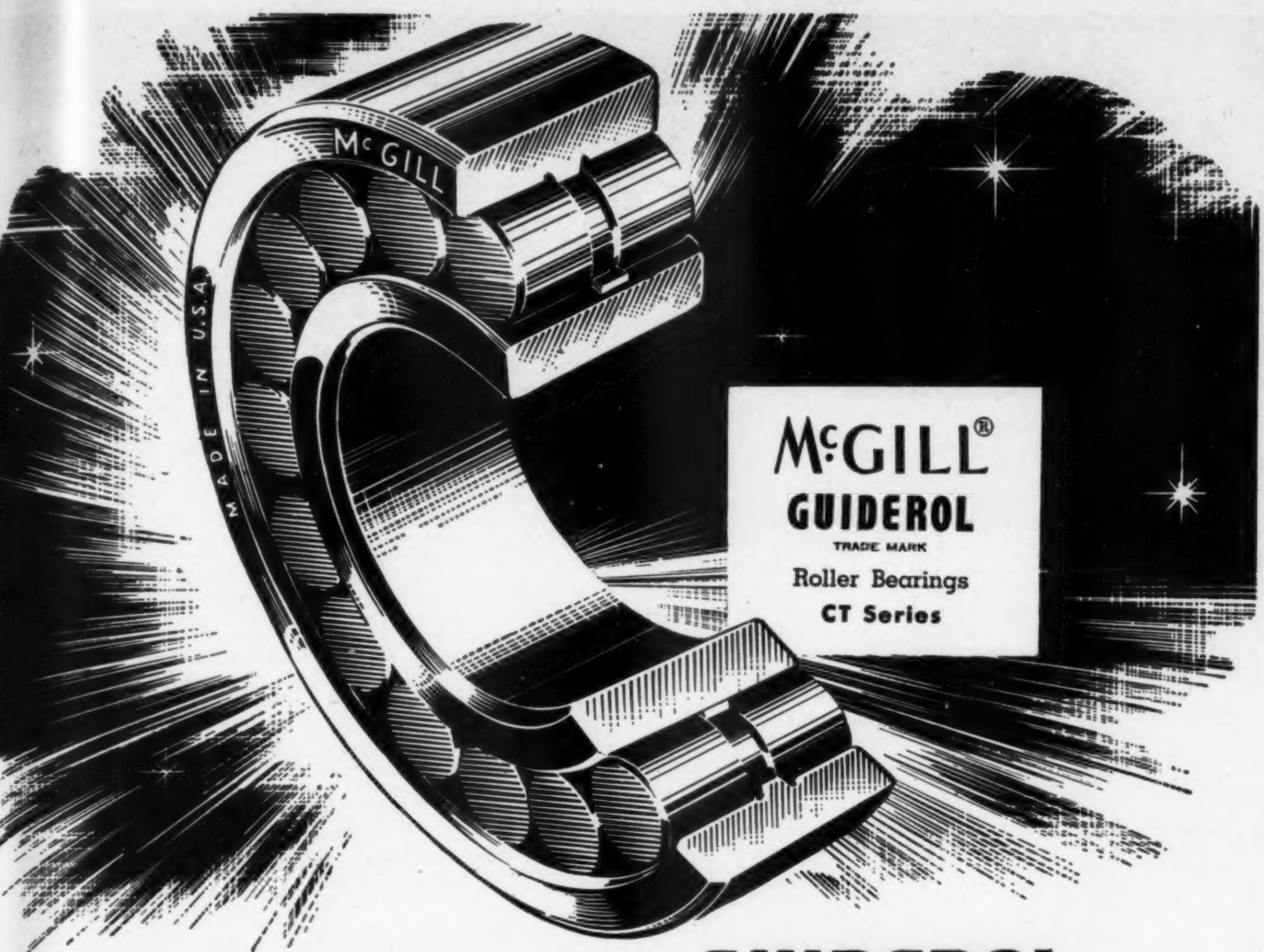
Designation: Enthox.

Form: Soluble powder, dissolved in water to 2 oz per gal concentration (½ to 4 oz per gal possible).

Service: Producing corrosion-resistant chromate coatings on zinc or cadmium, also zinc-base die castings; applied by immersion at 65 to 100 F temp; base for organic finishing.

Properties: Salt-spray resistance 200 hr on zinc, 500 hr on cadmium; produces iridescent, gold-colored coating varying from yellow to yellowish-brown depending on concentration and procedure; can be dyed black, red, blue, green, olive-drab and other colors with salt-spray resistance reduced about 10%.

For more data circle MD 30, Page 189



NEW PRINCIPLE of GUIDEROL

...solves your TOUGHER bearing problems

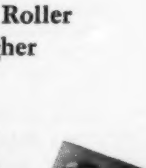
The McGill GUIDEROL Roller Bearing is especially designed to take advantage of the greater capacity of cageless roller bearings—without the danger of roller skewing. This new principle of bearing construction features guided rollers that overcome skewing tendencies and eliminate the need for space wasting cages. Also a much more rigid bearing results from extra long rollers that provide load support virtually the full width of the races. With GUIDEROL Roller Bearings you can expect rugged service with precision efficiency and longer life for your tougher bearing problems. Ask our engineers for the complete GUIDEROL story.

GUIDED ROLLERS PREVENT SKEWING—BINDING

Fig. A Fig. B

A guide rail on the inside diameter of the outer race maintains roller alignment. Normally no correction is required. Should misalignment cause tendency to skew, the guide rail touches grooved rollers back into position by momentary contact at Y. X indicates direction of roller rotation.

Bulletin GR-50 lists proposed standard sizes in CT Series (interchangeable with cylindrical type dimensions) for FT Series (interchangeable with ordinary needle type dimensions). Write McGill Manufacturing Co., Inc., 200 No. Lafayette St., Valparaiso, Indiana for your copy.



McGILL®
precision bearings

NEW PARTS AND MATERIALS

Electronic Counter 31

Berkeley Scientific Corp., 2200 Wright Ave., Richmond, Calif.

Designation: Model 10.

Style: Package electronic counter.

Size: 6⅝-in. wide x 7¼-in. high x 7-in. deep.

Service: Counting electrical impulses at rates up to 6000 per min; total capacity 9,999,999 counts; differentiates between impulses as close as 20 microseconds; can be operated from closing contacts, photocell or voltage pulse; on voltage pulse operation, decimal counting unit registers one count when positive potential of 2 v or greater applied; will accept slowly rising or quick pulse; for 117 v a-c operation, will operate from 105 to 130 v; draws 25 w; wiring moisture and fungus-proofed.

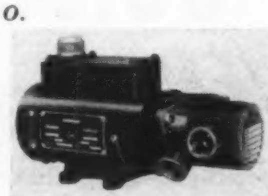
Design: Decimal counting unit displays unit digits; mechanical register shows remaining digits; reset button resets decimal counting register; thumb-wheel resets mechanical register; power and count switches; selenium rectifiers for power supply.

Application: Counting any mechanical, optical or electrical occurrences that can be converted into electrical impulses.

For more data circle MD 31, Page 189

Fuel Scavenge Pump 32

Lear Inc., Romec Div., Elyria, O.



Designation: Model RG-9020.

Style: Integral positive-displacement rotary-vane pump and d-c motor.

Size: 7-[illegible]in long x 2¾-in wide x 4$\frac{1}{32}$-in. high; ports for ⅜-in tube per AND 10050; weight 3.25 lb.

Service: Capacity at least 100 gph at 3500 rpm, 5 psi discharge at 17,000 ft. altitude; self-priming; displacement 0.179 cu in. per revolution; may be used with aromatic fuels; ambient air temperature, −65 to +160 F; fuel temperature, −65 to +135 F; motor, 0.033 hp compound wound, 27 v d-c, 2.5 amp max, continuous-duty explosionproof, with built-in radio noise filter—meets requirements of AN-M-10a.

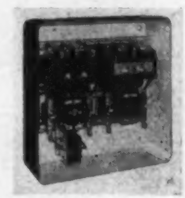
Design: Mechanical shaft seals and sealed drain port protect motor; Graphitar blades and bearings; no lubrication required other than fuel; 115 v, 400 cycle a-c motor-driven unit available with capacity 150 gph at 4000 rpm, 5 psi pressure; can be installed in any position with motor higher than pump; available with built-in relief valve.

Application: Removing fuel from aircraft manifolds after refueling or fuel-transfer operation.

For more data circle MD 32, Page 189

Part-Winding Starter 33

Allen-Bradley Co., 1326 S. Second St., Milwaukee, Wis.



Designation: Bulletin 736.

Style: Package unit consisting of two across-the-line starters with pneumatic timing mechanism.

Size and Service: Increment starting of a-c motors employing two separate star or delta parallel windings; ratings—size A 10 and 15 hp, size B 30 and 50 hp, size C 60 and 100 hp, size D 100 and 200 hp, size E 200 and 400 hp, at 220 and 440-550 v respectively, 50-60 cycles; 3 or 4 poles except E, 3 poles only; 60% of full-voltage locked-rotor current drawn by energizing first winding; timer energizes second winding after 4-second delay; each winding draws 50% of total current when motor running.

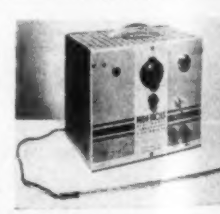
Design: Pressing *start* button closes first starter; pneumatic timer, mounted below starter, is operated by plunger; second starter is automatically closed by timer action; thermal overload relay; silver alloy contacts; available in open-type, general-purpose (NEMA 1), watertight (NEMA 4) or dust-tight (NEMA 5) enclosures.

Application: Air conditioning equipment, refrigeration systems.

For more data circle MD 33, Page 189

Temperature Control 34

Phen-Trols Inc., 15 Franklin Pl., Rutherford, N. J.



Designation: Model 100.

Style: Direct dial setting; electronic; thermocouple operated; portable.

Size: 9 in. wide x 8 in. high x 7 in. deep; weighs 12 lb.

Service: Direct dial setting temperature control of electric heaters or gas heaters (with solenoid valve) from 0 to 500 C; power circuit, 3000 watts, 30 amp if one load, 15 amp for each of two loads; sensitivity, ±0.5 C; 115 v, 60 cycle a-c operation; failure of any component opens power relay circuit; free from drift when used with double thermocouple.

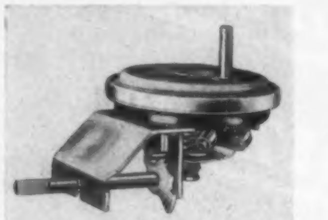
Design: Can be used with single or double iron constantan thermocouple; nonarcing sealed in glass mercury type power relay; 1 amp fuse for set, 30 amp fuse for power circuit; double outlet allows two identical operations to be controlled at once; vernier type temperature setting dial; fine adjustment knob; "set" and output light signals; similar model available for temperatures below 0 C.

Application: Heated molds, immersion heaters, liquid baths, ovens, furnaces, heating jackets.

For more data circle MD 34, Page 189

Pressure-Actuated Switch — 35

Acro Mfg. Co., Columbus 16, Ohio



Style: Diaphragm-actuated SPDT switch.

Size: Length, 4¾ in., height, 3¼ in.; diaphragm case diam, 3 in.; $\frac{5}{16}$-in. diam inlet tube.

Service: Switch actuation at three nominal pressures of 8, 9 or 10 in. water, also adjustable to 9, 10, 11 or 7, 8, 9 in. water; switch is rated 10 amp, 115 v a-c, SPDT.

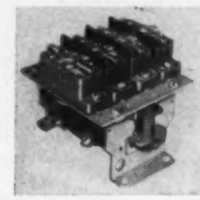
Design: Diaphragm movement is opposed by spring, with spring pressure adjusted by setting cam to one of 3 settings—3 settings also adjustable; rolling-spring, snap-action switch.

Application: Automatic washer water-level controls.

For more data circle MD 35, Page 189

Four-Pole Relay — 37

Square D Co., 4041 *N. Richards St., Milwaukee* 12, *Wis.*



Designation: Class 8501, type PO4.

Style: Precision snap switches actuated by magnet coil; 4-pole, double-throw.

Size: Approximately 4 in. long x 3½ in. wide x 3⅝ in. high.

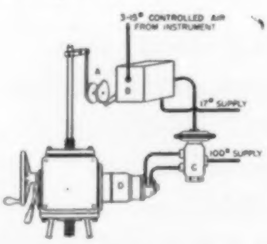
Service: Four normally-open or four normally-closed contacts by changing incoming wires; both sets of contacts available on circuits of same polarity; rated 10 amp noninductive, inductive ratings 5 amp at 600 v, 15 amp at 110 v; coils available for 6 to 600 v, 25-60 cycles.

Design: Each switch self-contained in melamine case; silver-to-silver contacts; laminated armature riveted to plastic actuating member; two shading magnet coils.

For more data circle MD 37, Page 189

Valve Positioning Control — 36

Conoflow Corp., 2100 *Arch St., Philadelphia* 3, *Pa.*



Designation: Rotomotor.

Style: Pneumatic with feedback.

Size: For valve stem travel to 36 in.

Service: For positioning large-size valves, dampers and large control elements used in throttling service; handles thrust loads to 60,000 lb, stem travel to 36 in., valve stem diam to 3½ in.; standard throttling stem speeds 8-12 in. per min, specials to 36 in. per min; accuracy 1.2% of total stem travel for total travels down to 2 in.; responds to control-instrument air pressure change of 0.025 psi; operating air pressure 70 to 100 psi, consumption, 3-4 cfm nonoperating, 15 to 50 cfm continuous operation; ⅛ to 3 hp motor.

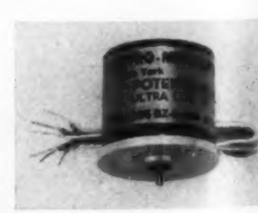
Design: Positioning device (B) determines actual valve stem position by means of stainless steel tape and cam connection (A) and desired position from air impulse from control instrument; corrected output pressure is fed from (B) to auxiliary pilot (C) which ports main air supply to pneumatic motor (D), driving gear box forward or reverse to reposition valve; self-locking stem; continuously-connected handwheel; roller-thrust or ball bearings enclosed in cast-iron gear box; positioning unit mounted inside weatherproof steel housing.

Application: Catalyst slide valves, paper machine pulp control valves.

For more data circle MD 36, Page 189

Low-Torque Potentiometer — 38

Electro-Mec Laboratory, 225 *Broadway, New York* 7, *N. Y.*



Designation: Type 1395.

Style: Toroid-wound with two electrically separate sections.

Size: 1.50 in. long with 0.42-in. shaft extension x 1.245 in. diameter; 0.078-in. diam shaft; mounting, ⅜-32 threaded boss; weight 0.79 oz.

Service: Two outputs for simultaneous recording or controlling; 24 standard sizes with resistances from 10 to 100,000 ohm, specials from 50 to 125,000 ohm; standard torques 0.008 to 0.006 oz-in., respectively, min 0.006 to 0.003, respectively, over standard resistance range; resolution, 0.159 to 0.064%; max current 0.036 to 0.003 amp; output, 0 to 100% of input voltage; linearity 0.5% or less, or nonlinear; maintains electrical continuity with vibrations in 0-60 cycle-per-sec range; acceleration to 15g; −55 to +95 C ambient temperature with wire coefficient as low as ±0.00002 ohm per ohm per deg C; insulation resistance, 400 rms v, 60 cycle a-c at 25C for 1 min at sea level.

Design: Mechanically continuous rotation of gold or palladium-alloy brush; bearings, miniature precision (ABEC-5) ball or sapphire jewel, with dust caps; silver-plated brass terminals; all parts corrosion-resistant with stainless-steel fasteners; wire resistance element corrosion-resistant or platinum alloy; insulation fungicide-treated.

For more data circle MD 38, Page 189

NEW PARTS

Silver-Coated Steel 39

American Silver Co. Inc., 36-07 Prince St., Flushing, N. Y.

Designation: Braze-Clad.

Form: Steel coated with silver brazing-alloy.

Size: Strip—0.005 to 0.125-in. thick, ⅛ to 8 in. wide coated with 0.0003 to 0.005-in. thick silver brazing alloy on one or both sides; bar stock to 1 in. thick.

Service: Gives complete and uniform spread of brazing alloy without oxide islands, gas pockets or flux inclusions; prediffusion controls flow of brazing metal.

Properties: Thickness ratio and melting range to specifications; low-carbon steel, soft to spring-hard.

Application: Automotive, aviation, refrigeration, electrical, electronic products.

For more data circle MD 39, Page 189

Adhesive Felt 40

Products Research Co., 5426 San Fernando Rd., Glendale 3, Calif.

Designation: Kling.

Style: Reinforced felt with pressure-sensitive adhesive back.

Size: Rolls from ¼ to 66 in. wide; thicknesses of 1/64, 1/32 and 1/16-in. in 100-ft lengths; ⅛-in. thick in 50-ft lengths; ¼-in. thick in 25-ft lengths; die-cut gaskets to specifications.

Service: Sealing, sound-deadening, thermal insulating, vibration and shock cushioning, damage protection; adheres with finger pressure; resists age deterioration and frictional wear; requires no separation material between layers when rolled up.

Design: Reinforced felt backed with pressure-sensitive adhesive on one side.

Application: Control panel doors, weather-sealing, antisqueak and sealing on truck cabs, instrument cushioning, packaging.

For more data circle MD 40, Page 189

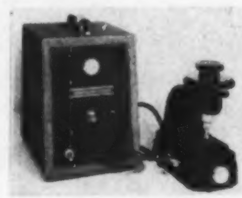
ENGINEERING DEPARTMENT

EQUIPMENT

For additional information on this new equipment, see Page 189

Electronic Micrometer 41

J. W. Dice Co., 1 Engle St., Englewood, N. J.



Designation: Carson-Dice, Model M.

Style: Precision micrometer with electronic on-off indicator.

Size: Micrometer, 7 in. high x 4 in. wide x 6 in. deep; electronic unit, 9 in. high x 8 in. wide x 6 in. deep; ⅛-in. diam anvils; 3-in. diam dial.

Service: Direct micrometer readings to 0.0001-in., 0.00002-in. by interpolation; anvil pressures, ¼, 2, 4 and 8 oz with interchangeable springs; ⅛-in. measuring range; electronic circuit gives positive on-off indication with 10-millionths in. anvil displacement in 0 to 0.025-in. range, 25-millionths in. in 0 to 0.125-in. range; 110 to 130 v a-c operation; index adjustable.

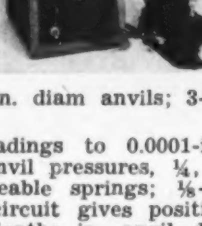
Design: Dial has white, 0.0001-in. divisions on black background, each 0.001-in. numbered, 0.025-in. per revolution; anvils lapped flat and parallel to 10-millionths in., can be furnished in $\frac{1}{16}$-in. diam size or spherical; lower anvil retracts; electronic unit has indicator and pilot lights, line switch.

Application: Measuring hard, soft, compressible, conducting or nonconducting materials, deflections in diaphragms, bellows, springs.

For more data circle MD 41, Page 189

Pressure Measuring Instrument 42

Electro Products Laboratories, 45 N. Ravenswood Ave., Chicago 40, Ill.



Designation: Pressuregraph.

Style: Separate electronic pick-up, package power supply and electronic circuit, and oscilloscope.

Size: Cabinet, 12 in. high x 7 in. wide x 17 in. deep, weight 25 lb; pickup, 6½ long x 1⅛ in. diam with 14, 18 mm or ⅞-18 std spark-plug mounting threads or ¼-in. pipe thread.

Service: Linear response on oscilloscope trace to pressure changes from 0.5 to 10,000 psi; frequency response, 0 to 20,000 cps; 200,000 measurements per sec; accuracy, 1% full scale or rated diaphragm pressure; full-scale output, 1 mv across 100,000 ohm or 0.003-amp through short; output as either modulated 200 kc carrier or d-c voltage; max pickup temperature uncooled, 250 F; air or water-cooling available; power, 60 w, 115/230 v, single phase, 50/60 cycle.

Design: Carrier voltage from power supply circuit is modulated by pickup diaphragm; for use with DuMont 304-H or 208-B oscilloscope or equivalent.

Application: Testing jet, gasoline and diesel engines, superchargers, air compressors, injection pumps.

For more data circle MD 42, Page 189

Time-Pulse Marker 43

Berkshire Laboratories, 602 Lexington Rd., Concord, Mass.

Designation: Labmarker.

Style: Package converter.

Size: Overall length, 5½ in.; diam 1½ in. except 1-U1, 1¾ in.

Service: Converting sinusoidal input into sharp unidirectional timing pulses of approximately 1/10-cycle duration; amplitude 1/20 rms input voltage; model 1-U1 has outputs for plus or minus pulses, spaced 180 deg; model 1-N1 provides minus pulses only, 1-P1, plus only; frequency range, 25 cycles to 1 mc; 36 v, rms input voltage.

Design: Model 1-U1 has 4 output binding posts taking leads having single or double banana plugs, spade tips or plain wire ends, other models have 2 posts; operates from a-f or r-f oscillator.

Application: Forming pulse time-marks by connecting output to oscilloscope vertical input; forming timing breaks in trace by connecting output to "Z" input terminals.

For more data circle MD 43, Page 189

Miniature Steam Generators 44

Palo Laboratory Supplies Inc., 81 Reade St., New York 7, N. Y.

Designation: ES-3, -5, -10, -15.

Style: Electric, automatic.

Size:

Model	Boiler Size (diam x height, in.)	Water Capacity (gal)	Weight (lb)
ES-3	7½ x 16	2	140
ES-5	11½ x 18	4	175
ES-10, -15	11½ x 27	8	220, 235

Service: Generating steam at automatically regulated pressures from 0 to 30 psi, or working pressures to 100 psi; approved by UL; ASME code boilers; model designation indicates kw capacity;

Model	Equivalent Boiler Hp	Voltage	Phase
ES-3	¼	110-220, a-c, d-c	1
ES-5	½	220-440, a-c, d-c*	1 or 3
ES-10	1	220, a-c*	3
ES-15	1½	220, a-c*	3

* Includes magnetic contactor, toggle switch, low-water cutoff.

Design: Steel-plate welded boilers; rock-wool insulation; submerged heating elements; automatic pressure regulator; include safety valve, steam pressure gage, water gage; Mercoid low-water cutoff control.

Application: Laboratory work; ES-5—steam jacketed equipment; ES-10, -15—vulcanizing machines, cleaning.

For more data circle MD 44, Page 189

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HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

75. Reduction Clutch

Snow-Nabstedt Gear Corp.—Design information regarding the No. 5107 reduction clutch is presented in 1-page illustrated data sheet. This compact unit transmits 2 to 12 hp and offers 1.75 to 1 reduction in both directions.

76. Electrical Insulation

Irvington Varnish & Insulator Co.—Entitled "Irvington Class H Insulation", 16-page illustrated bulletin offers electrical and mechanical properties, standard thicknesses, lengths and widths of silicone varnished Fiberglas, silicone glass mica, silicone saturated and silicone coated asbestos, silicone rubber coated Fiberglas and Silastic tape.

77. Filters & Cartridges

Fram Corp.—32-page illustrated industrial catalog No. FCI-89 deals with complete line of oil filters for use on diesel, gas and gasoline engines. Types and sizes are described for marine, stationary and mobile service. Micronic filtration is provided by Filcron cartridges which remove abrasive and solid materials as small as 1 micron.

78. Tube Steel Impact Test

Babcock & Wilcox Tube Co.—2-page data sheet quotes impact properties of tubing steel at room and elevated temperatures. Information can be used as guide to engineers studying design and operation of equipment subjected to impact stresses at high temperatures.

79. Molded Rubber Parts

Stowe-Woodward, Inc.—16-page illustrated booklet describes design, development and manufacturing facilities of company, a producer of molded rubber parts. Descriptions of specific projects, engineered to operate in extremes of heat and cold and in harsh oils and solvents, are included.

80. Brazing Applications

Handy & Harman—4-page illustrated folder No. 54 relates how Easy-Flo and Sil-Fos low temperature silver brazing alloys have speeded production and reduced costs. Case studies show that formed pieces of brazing alloy used for preplacement boost production.

81. Conveyor Roll Bearings

Arguto Oilless Bearing Co.—Illustrated data bulletin No. 200 covers range of standard sizes and characteristics of oilless wood conveyor roll bearings. Impregnated with nonoxidizing lubricant, they are perpetually self-lubricating, unaffected by water or abrasives and will not drip. Diagrams explain simple design and installation directions for new or old installations.

82. Voltage Regulators

Superior Electric Co.—12-page illustrated bulletin S351 relates how Stabiline automatic voltage regulator maintains constant output voltage regardless of variations in alternating current input line voltages and changes in output load. Type IE is electronic, while type EM consists of electronic detector circuit controlling motor-driven Powerstat variable transformer. Rating chart facilitates selection of unit for specific application.

83. Air-Cooled Engines

Wisconsin Motor Corp.—6-page illustrated brochure S-130 features heavy-duty air-cooled engines designed for use in construction, railroad, industrial and oil fields. Dimensional drawings, charted power curves and specifications are presented on single cylinder 3 to 9-hp engines and 2 and 4-cylinder, 7 to 30-hp engines.

84. Snap-Action Switches

Minneapolis-Honeywell Regulator Co., Micro Switch Div.—4-page condensed circular No. 54 catalogs the following types of over 5,000 snap-action switches: heavy duty limit, medium duty limit, explosionproof, high-capacity enclosed, die cast enclosed, basic and V3 switches, as well as actuators.

85. Flexible Shafting

Elliott Mfg. Co.—All factors related to design and application of flexible shafting for power drives are presented in 8-page illustrated bulletin 4b/EL. Carried in stock are 108 types and sizes of cores ranging in diameter from 3/16 to 1⅛. Data are given on casings, minimum radius of bend, dynamic torque and typical core and casing fittings.

86. Hydraulic Pumps

Oilgear Co.—Three new constant-delivery axial-piston pumps for pressures up to 3000 and 5000 psi are described in 4-page illustrated bulletin 46601. These pumps are suited for hydraulic power applications involving pushing, pulling, lifting, lowering and maintaining high static loads.

87. Speed Indicator

Metron Instrument Co. — Designed for measuring speeds of two to ten machines in single instrument, series 42R tachometer indicator is of multiple head type and is described in illustrated data sheet No. 42R. Unit can be installed wherever desired and connected to tachometer heads on various machines by simple wiring.

88. Motors & Generators

Kurz & Root Co.—2-page illustrated general information sheet outlines equipment made by company which includes 1 to 10-hp alternating current motors, 1 to 100-hp direct current motors, ¾ to 125-kva alternating current generators, ¾ to 100-kw direct current generators and motor-generator sets.

89. Spot Welding Data

Ampco Metal, Inc.—Recommended schedules for spot welding low carbon steel are listed in 8½ x 11-in. reference chart which is punched to fit any three-ring binder.

90. Swivel Pipe Joints

Chiksan Co.—20-page illustrated catalog No. 50-D contains design and application information on complete line of ball-bearing swivel joints for petroleum, chemical and industrial service. Sizes range up to 12 in. for wide range of pressures.

91. Thermostatic Bimetal

W. M. Chace Co.—"How Chace Put Buy-Metal into Our Product" traces various steps in selection and application of thermostatic bimetal in electric appliance. Also shown are various production operations in producing thermostatic bimetal elements.

92. Fractional Horsepower Gearing

Gear Specialties Inc. — Fractional horsepower gearing from 12 to 96 diametral pitch is subject of 6-page illustrated folder. Typical types designed for various applications are shown. Also covered are manufacturing facilities of company.

93. Standard Screw Products

Standard Pressed Steel Co.—Booklet entitled Unbrako "Standards" contains detailed information about socket head cap screws, self-locking socket set screws, socket set screw points, flat head socket cap screws, shoulder screws or stripper bolts, Dryseal-Thread pressure plugs, socket screw keys, square head set screws and precision-ground dowel pins.

FOR MORE INFORMATION

on developments in "New Parts" and "Engineering Department" sections—or if "Helpful Literature" is desired—circle corresponding numbers on either card below

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94. Sheet Packings

Raybestos-Manhattan, Inc., Packing Div.—A complete line of R/M asbestos and fiber sheet packings including woven asbestos wire inserted, Pyroid, Navy grade Dreadnought and compressed asbestos sheet packings and Duroil fiber sheet is described in 8-page illustrated bulletin. Service recommendations, standard sheet sizes, weights and thicknesses are given for each packing.

95. Twist Drills

DoALL Co.—12-page illustrated catalog No. 51-816 describes line of taper shank, straight shank, three fluted and four fluted drills; drill sets; chatter-free countersinks; combination drill-countersinks; hardened and ground sleeves and sockets; and carbide-tipped masonry drills. Included are charts on drill speeds and feeds, decimal equivalents of drill sizes and tips on drill pointing and web thinning.

96. Control Units & Stations

Allen-Bradley Co.—16-page illustrated bulletin 800T deals with oiltight control units and stations for pilot control of both alternating and direct current magnetic contactors and motor control apparatus. Start, stop, maintained contact, mushroom head, selector, locking, tandem contact, jogging and pilot light types are some of the many control units described. Assembled control stations include pendant type.

97. Electronic Engineering

Electronic Engineering Associates, Ltd.—Facilities available for electronic design, development and production are described in 8-page folder SA7-651. It also shows number of products designed for aeronautical research, carrier power measurements, low-frequency transmission and ultra-high-frequency propagation study.

98. Plastic Products

General American Transportation Corp., Plastics Div.—"More Men and Machines To Produce Your Products of Plastics Better" is title of 12-page illustrated bulletin which shows production facilities which are available to engineer and make injection and compression molded as well as reinforced plastic parts to user's specifications.

99. Print Duplicator & Developer

Charles Bruning Co.—4-page illustrated folder offers information and specifications on BW-Copyflex model 2 Continuous Printer and model 153M EW Continuous Developer for duplicating typed, printed, illustrated or drawn work.

100. Chromium-Nickel Alternate

Republic Steel Corp.—12-page illustrated booklet "A Guide to Type 430 Stainless Steels as Alternates of the 18-8 Series" compares this no-nickel stainless with types 302 and 304, restricted because of nickel content. Drawing, forming, welding and polishing of 430 is discussed.

101. Spring Loaded Clutches

Borg-Warner Corp., Rockford Drilling Machine Div.—Dimensional diagrams and full specifications are given in single data sheet entitled "Rockford Spring Loaded RM 8, 8½, 9, 10 and 11 Inch Clutches." Clutches are well adapted to foot pedal use, or where cushioning engagement of drive unit is required.

102. Stamped Textured Metal

Rigidized Metal Corp.—8-page illustrated folder CF1 explains how Rigidized design-strengthened textured metals conserve alloys, minimize weight and increase strength. Available pattern, typical applications, weight savings and advantages of this textured sheet metal are covered.

103. Battery-Charging Equipment

Electric Products Co.—4-page bulletin 11-210 is descriptive of E.P. single-circuit battery charger for industrial truck lead-acid and Edison batteries. Illustrations, drawings and tabulated ratings are included.

104. Polyvinyl Chloride Resins

B. F. Goodrich Chemical Co.—12-page bulletin G-6 outlines applications and physical properties, and graphically shows tensile and flexural strengths, modulus of elasticity, heat distortion, impact and chemical resistance and Clash-Berg stiffness of Geon Resin 404. Processing methods and recipes for calendering, extrusion and molding are given.

105. Self-Contained Cylinders

Ledeen Mfg. Co.—12-page illustrated bulletin 500 offers descriptive data on medium, heavy and super duty self-contained cylinders designed for push-pull, lift-lower or press-squeeze operations. Features; selection; charted ratings, limitations, dimensions and weights; plus drawings and specifications of rod and head attachments are presented.

106. Worm-Gear Speed Reducers

Cleveland Worm & Gear Co.—"Finest in Worm-Gear Drives" is title of 8-page bulletin that cites performance of speed reducers as drives for such equipment as cooling tower, woolen card, pickling machine, mine conveyor and mixer.

107. Die Casting Facilities

New England Die Casting Co.—24-page illustrated booklet "The Inside Story" discusses personnel, machines and plant facilities which are available for the production of die castings. Typical parts produced to customer's specifications are shown.

108. Centrifugal Governors

Pierce Governor Co.—"How to Get the Most Out of Your Governor" is outlined in 12-page illustrated bulletin of this title. Operation and application of governors for control of engine speed are discussed. Described are constant speed, variable speed, long range, automotive and overspeed trip types of governors.

109. Circuit Breaker Panelboards

Westinghouse Electric Corp.—Line of 10 to 600-amp De-ion circuit breakers and panelboards for protecting lighting, appliances and other power applications is described in 20-page booklet B-5260. Panelboards provide maximum adaptability to unpredictable load changes.

110. Rubber Antioxidant

Goodyear Tire & Rubber Co.—A nondiscoloring and nonstaining antioxidant for rubber, Wing-Stay S, is subject of technical bulletins WS-100-3 and WS-100-4. Former deals with use of products in rubber compounds, while latter gives data on its use in shoe sole compounds.

111. Oil Hydraulic Cylinders

Commercial Shearing & Stamping Co.—Illustrations, drawings, tabulated dimensions, ratings and types of mountings and fittings for telescopic oil hydraulic cylinders suitable for pressures up to 1500 psi are fully covered in 56-page catalog H-3. Typical field applications are shown.

112. Heat-Resistant Paint

Speco, Inc.—Application and product data for five heat-resistant paints are covered in bulletin L-4261. Included are: Heat-Rem (Standard) Aluminum; Heat-Rem H-170 Extra High Heat Aluminum; Speco "M" Aluminum for moderately hot surfaces; Speco "HSE" (hot surface elastic) Black; and Speco "QD" (quick drying) Black.

113. Variable Speed Motor Pulley

Gerbing Mfg. Co.—Designed to provide speed variation up to 4 to 1, Roto-Cone variable pitch pulleys have infinite adjustment within that range and are available in ratings from fractional to 15 hp. By utilizing two pulleys, speed variation up to 9 to 1 is possible. Complete design and application data are given in 32-page illustrated catalog No. 651.

114. Hydraulic Hose & Fittings

Eastman Mfg. Co. — 64-page illustrated loose-leaf catalog "Hydraulic Hose Assemblies, Couplings and Accessories" is divided into six sections which give complete engineering and application data on one-wire braid hose and assemblies, two and three wire braid hose and assemblies, fabric braid hose and assemblies, spiral wire hose and assemblies, adapter unions and miscellaneous fittings.

115. Roller Chain Sprockets

E. B. Sewall Mfg. Co.—Dimensions and list prices of series of sprockets designed for standard roller chains are tabulated in 68-page illustrated catalog No. 51. Included are plate sprockets without hubs, sprockets with cast iron hub and one and two-sided hub projections. Section on Atlas Roller Chain is offered.

116. Air Control Valves

Logansport Machine Co.—Revised edition of Logan Air Control Valve catalog 100-4 provides up-to-date engineering data, illustrations and drawings on additional valve models. Revision effects pages covering light-duty two-position four-way valves, two and three-way valves and poppet-type hand control valves.

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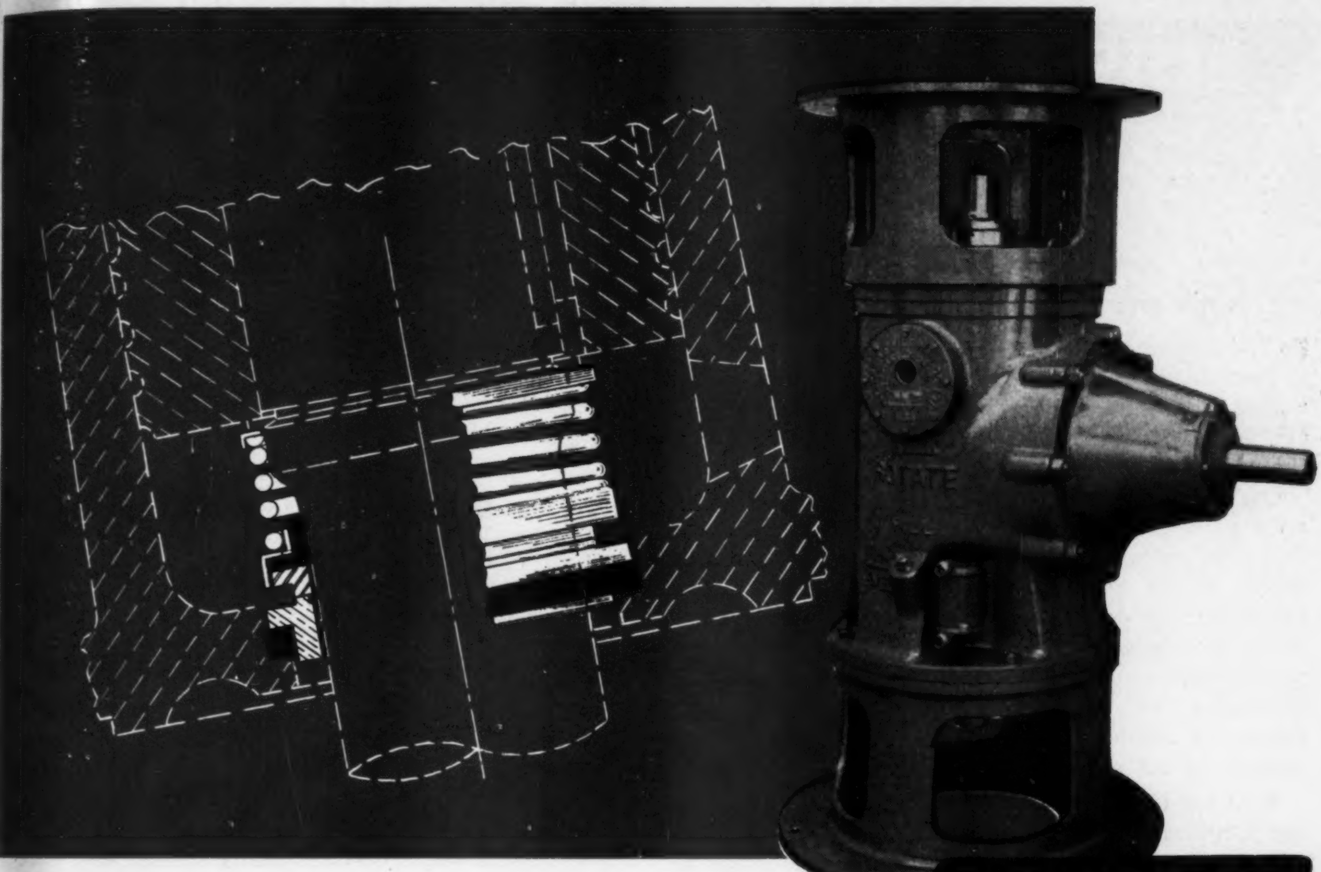


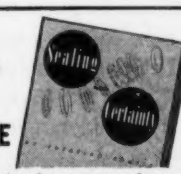
Shaft-Sealing Certainty for JOHNSON GEAR—with

ROTARY SEALS

The gear drives produced by Johnson Gear & Mfg. Co., Ltd., of Berkeley, California, are used in all kinds of rugged applications, both here and abroad. Units like the one illustrated, for a dry dock installation in Venezuela, must be designed for day in and day out performance without frequent down-time for repairs to an old-fashioned Shaft Seal. That's why you'll find ROTARY SEALS in units throughout Johnson's line—to provide *Certainty* in that critical factor of Shaft Sealing.

Most ROTARY SEALS are specially adapted for a given application from the basic ROTARY SEAL principle. Our engineers, experienced in the solution of Shaft Sealing problems for manufacturers large and small in many widely varying fields, will be glad to consult with you on *your* requirements. It's wise to call us in at the drawing board stage—we can often suggest the simplest design approach from the Shaft Sealing Standpoint, based on successful jobs in many lines.

THE ROTARY SEAL PRINCIPLE



is the original approach to a practical solution of a universally troublesome problem. Our booklet "SEALING WITH CERTAINTY" explains and illustrates the principle. We're glad to send it to you without obligation.

THE ROTARY SEAL COMPANY
mechanical seals for rotating shafts

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CHICAGO 14, ILLINOIS, U.S.A.

Professional Viewpoints

"... will give young engineers misconceptions"

To The Editor:

Your June 1951 issue contains an article on "Evaluating Engineers". The opening paragraphs of this article have provoked me into writing a "letter to the editor".

Our company, along will all others, is finding it difficult to maintain an adequate engineering staff. Our problem is no different from that of all manufacturers whose business is expanding. We suffered losses during the war years, and the establishment of a retirement program reduced the number of experienced men on our staff. In the light of these conditions, we are making every effort to employ competent engineering graduates, and properly compensate those engineers now in our employ.

It is my belief that your June article on "Evaluating Engineers" will give the young engineer definite misconceptions and add to industry's difficulties in obtaining an adequate number of engineering graduates. The author infers that 1950 enrollments are down because of the poor compensation granted to engineers. It is true that the 1950 enrollment is down, but other factors are involved. One of the most important factors is the low birth rate which prevailed during the depression years. The second factor is the propaganda circulated several years ago, claiming that the large number of graduates under the G. I. Bill of Rights would create an oversupply. A third factor is the number of high school graduates who find it necessary or desirable to enter the Armed Forces. Many of these young people will ultimately enroll in engineering colleges.

However, the statement to which I take particular exception is that in which the author states, "Advancement from one bracket to the next higher is more a result of chance, favoritism or showmanship than of pure merit. It is easier to keep the good draftsman on the board and to hire in a new designer, than to help the draftsman advance himself." No doubt the conditions to which the author refers do exist. Is their existence so common as to justify such a generalization?

The writer's employers, as well as many other engineering employers, do have effective job evaluation programs. Statements of the type quoted above cannot help but discourage young engineering graduates and add to their confusion. We have gone through all the phases of job evaluation as applied to engineering and technical personnel. We have found that evaluation programs are useful. However, they are not a substitute for a proper understanding of the peculiarities and specialized abilities of individuals. Your author admits to having no background of experience with job evaluation in "Creative Engineering." This may be a source of his difficulty.

—D. L. PELLETT
Manager, design and construction
The B. F. Goodrich Co.

"... remarks do not apply to enlightened employers"

To The Editor:

From the point of view of the B. F. Goodrich Co., a most enlightened employer of creative talent, Mr. Pellett's criticism is well founded and has my complete respect. I am well acquainted with two Goodrich engineers and have observed at close range their loyalty and enthusiasm for their jobs and their company.

In writing as I did, in a critical tone, I risked the ire of the few enlightened employers to whom my remarks do not apply and Goodrich is one of these. However, I had a definite dual purpose. One part of that purpose was to seize upon the imagination of run-of-mine unenlightened employers of creative engineers and to stimulate some realistic thinking about their responsibilities to the profession. The second part of that purpose was to help the young engineer to become more selective in choosing his career channel and to have a superior respect for the employer who offers tangible evidence of preparedness to recognize the engineer's future contributions. If my efforts in this direction have any success, the standing of the B. F. Goodrich Company will be enhanced.

Mr. Pellett takes particular exception to my contention in regard to advancement. This is not literally true in every industrial enterprise but, as a consulting engineer, I have observed it to be true in all but a very few of the many companies I have served. The existence of those irrelevant forces is sufficiently common to justify that generalization.

At this point, I am apart from Mr. Pellett on but one point. While it was true that my associates and myself had no background of experience with job evaluation in creative engineering at the time that we undertook to apply it, we did gain a wealth of experience thereafter and, in addition, I have acquired further practical experience with the subject in more recent professional engagements.

—RANDOLPH W. CHAFFEE

"... should bring understanding to design engineers"

To The Editor:

The article "Evaluating Engineers" appearing in the June issue of your magazine certainly is worthwhile reading. It should bring understanding and

Case History M-105

Here's what we mean by SUPERIOR ENGINEERED FOUNDRY PRODUCTS...

PROBLEM:

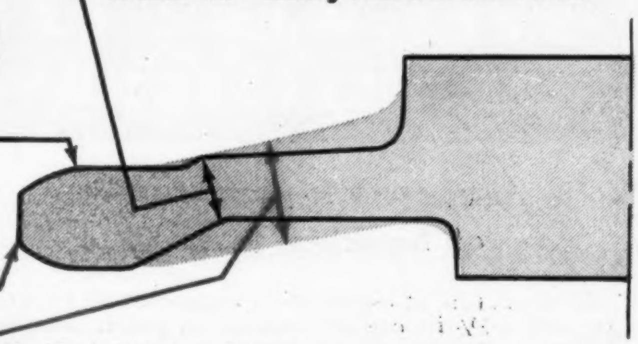
1. Conventional design of cast steel sprocket blank impaired proper directional solidification of the metal, causing uncontrolled shrinkage in the outer rim.
2. Assurance of delivery of sound castings was possible only through expensive non-destructive inspection of each blank.
3. Casting and machining losses were excessive.

OUR SOLUTION:

FOUNDRY ENGINEERED DESIGN to establish a relationship of tooth, web and hub sections which would insure uniform directional solidification of the metal, place metal where needed most and minimize necessity for expensive inspection of each part.

B Metal becomes solid at thin section first, cuts off all feeding action from heavier center section to outer rim — causing occasional shrink holes

A Heavy outer rim required excessive feeding risers in addition to the large riser needed for feeding the heavy center section.



A Metal solidification starts at thinnest point and progresses toward heavier center section requiring only one feeding riser.

B Modified design gradually increases section from outer rim permitting metal to become solid progressively toward hub, eliminating shrink holes.

RESULT: 17.6% SAVINGS

1. Elimination of shrink holes in outer rim through proper directional solidification of the metal.
2. Elimination of need for expensive inspection of each part.
3. Reduced casting and machining costs.

BLACK LINES . . . . ORIGINAL DESIGN

RED LINES . . . . . MODIFIED DESIGN

TOTAL COST OF PART REDUCED 17.6%

YOU TOO CAN GET SAVINGS LIKE THIS! CONSULT OUR PRODUCT DEVELOPMENT SECTION REGARDING YOUR PROBLEM . . . WHILE IT'S STILL ON THE DRAWING BOARD!

LET OUR FOUNDRY ENGINEERS HELP YOU CONSERVE CRITICAL MATERIALS

ENGINEERED FOUNDRY PRODUCTS

Since 1916

SUPERIOR STEEL AND MALLEABLE CASTINGS CO.

BENTON HARBOR, MICHIGAN, U. S. A.

TO KEEP YOUR CASTINGS COMING . . . KEEP YOUR SCRAP GOING TO THE FOUNDRIES

help to the engineering profession as a whole, but in particular to design engineers as a group.

I have been exercised for years concerning the lack of interest most young men have in following a career such as machine design. It is possible that with a better understanding of what the true needs of a machine designer are and the proper evaluation of these needs, something will be done about it. At least that is my hope.

Mr. Chaffee should be complimented on this presentation and your magazine for presenting it.

—L. F. NENNINGER
Works Manager
The Cincinnati Milling Machine Co.

"... librarians equal to janitors?"

To The Editor:

In the article "Evaluating Engineers," which appeared in the June issue of MACHINE DESIGN, I was particularly moved by Mr. Chaffee's evaluation of librarians on a scale equal to janitors and switchboard operators and one step below secretaries and junior accounting clerks. This rating hardly seems to acknowledge the professional training and standards of librarians and appears to be based on a strictly clerical rather than professional interpretation of the librarian's job.

This is all the more surprising in these days when modern training for a technical librarian has become more extensive and more specialized as their contribution to business progress is appreciated.

It seems particularly surprising that such an evaluation could be made in Cleveland which has such an excellent public library with its world famous business information service; an outstanding university for library training at Western Reserve; and also a group of fine technical libraries well staffed by librarians whose professional training would rank them as specialists in their fields. It seems too bad that such a poor job was done on this particular evaluation in an otherwise interesting and thought provoking article and in a magazine which has wide circulation among design and production engineers.

I think it would be worth-while sometime in the future to publish an article which would bring the engineer up-to-date on the modern training of librarians, their technical background, and the worthwhile assistance he might obtain from his library.

—MARY D. QUINT
Librarian, American Optical Co.
Southbridge, Mass.

"... have not recognized value of trained librarians"

To The Editor:

I am most pleased to have the comments of Mary D. Quint on my apparently low evaluation of the librarian's job. It is primarily to stimulate discussion and learn thereby that I undertake to disseminate my ideas.

Within any one job title, the job content may vary widely in different industrial organizations. Taking

Miss Quint's job, for example, the job content undoubtedly includes search, review, interpretation, analysis and technical understanding of published technical material related to the optical arts and sciences. Doubtless she is called upon to compose digests of such information, to determine which members of the technical staff will be interested in the information, and to see that it is brought to their attention. Possibly she, like technical librarians in public libraries, is trained to study, analyze, interpret and correlate patent specifications, to assist in patent research and otherwise to employ independent judgment in the processing of technical information.

This job content certainly would evaluate much more highly than the one included in my article. In many engineering organizations, the job content is restricted to maintaining the subscription list, routing periodicals to interested staff members and generally carrying out a prescribed routine, with no latitude for independent judgment or responsibility.

In my opinion, commercial engineering organizations have not learned to recognize the true value of the trained, technical librarian and the enormous help that this job can be to the engineering and design staff. Certainly it would be most helpful to me if someone were reviewing the current art, selecting that which is of prime interest to me, digesting it and relating it to my current projects and bringing it to my attention at the critical moment.

—RANDOLPH W. CHAFFEE

Editor's note: In explaining the evaluation of jobs shown in the table referred to by Miss Quint, the author points out that the table is an example worked out for one particular job and that "in another creative engineering organization, these duties will differ markedly as will the evaluations."

They Say...

"We cannot relax in the development of our *industrial, agricultural, and technological equipment.* In the world we live in today it is essential that we keep our productive system efficient and up-to-date, and we must provide for its steady, constant expansion. We cannot afford to let our tools grow dull. They must be the best in the world, because the tools of world freedom are the tools of American production. If ever the times called for keeping our productive equipment oiled, manned and efficient it is today."—W. WALTER WILLIAMS, *president, Continental Inc., Seattle, Wash.*

"The industrial revolution made muscle-power obsolete. The technological revolution now underway, wherein routine work is being taken over by electronic machines, will make unnecessary jobs where a person performs repetitious operations as a mere reflex, without thought. For example, if a system of addressing letters with certain code markings were adopted, an electric eye could scan mail, and signal sorting machinery could then route pieces of mail to their proper slots, even into the mailbag of the proper mailman."—WILLIAM C. WHITE, *General Electric Research Laboratory.*

Organizing an Engineering Data File

(*Continued from Page* 116)

ences are scanned in ten minutes (one reel of master film), and during this time all applicable material is automatically photographed on a copy film for delivery to the operator. The machine is known as the Microfilm Rapid Selector and was developed jointly by the U. S. Departments of Agriculture and Commerce.

The Microfilm Rapid Selector is obviously far beyond the budget or needs of the ordinary engineering reference library. However, most of the other data filing methods discussed in this article make very reasonable demands on time and money, and such systematizing should yield a fine return in better, lower-cost design.

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Dedicated to the Engineer

Here is a tribute to the engineer, from the title page of Pitney-Bowes annual report for 1950:

"To the engineer in Pitney-Bowes—and to the engineer in American industry—we dedicate this thirty-first Annual Report, recognizing the decisive but seldom-sung role of the Man with the Slide Rule in the progress of our company, and in the growth of our country. At this hour, we are profoundly aware of the production engineer and his partner, the development engineer—and their team mates in drafting room and tool room, in model shop and machine shop—who labor in proud anonymity to bring the dreams of free, enterprising men from the potential of the drawing board to the reality of the production line. Today, an America that seeks peace, yet must arm for war, again calls upon this unique man of industry to tool up the nation for another great battle of production. In peace or in war, we trust this man with the brains, the know-how, and the calm self-effacement. And we salute him, wherever he is . . . in the vast aircraft plant, the precision business machines factory, or the back alley shop. Let us use with skill and faith the tools of freedom he is designing . . . ."

Inventions

(*Concluded from Page* 122)

clearly this principle of law that governs the disposition of patents conceived and perfected by an employee during a term of employment.

"A patent is property, title to which passes from the inventor only by assignment, and an agreement to assign will be specifically enforced. As between employer and employee, rights are determined upon the contract of employment. The law is fairly clear. In the absence of a contrary understanding, the mere existence of an employer-employee relationship does not entitle the employer to ownership of an invention of the employee.

"This is true even though the employee uses the time and facilities of the employer, although the latter in that event may have shop rights therein, that is a right to a free, nonexclusive, personal license to use the invention in his business. On the other hand, if an employee is hired to invent or is assigned to a particular problem the resulting invention belongs to the employer."

The law governing the ownership of inventions, aside from this shop right, was recently outlined in an action that came before the United States Supreme Court for decision.

An employee in the radio laboratories of the United States Bureau of Standards, wrestled with the problem of substituting house lighting alternating current for the direct battery current then used exclusively in radio apparatus. He was successful. Later the government claimed an exclusive right to these inventions on the basis of his employment by the United States.

"One employed to make an invention," asserted Justice Jackson of the United States Supreme Court in the rendering of the decision in the action later brought by the government, "who succeeds during his term of service in accomplishing that task, is bound to assign to his employer any patent obtained. The reason is that he has only produced that which he was employed to invent. His invention is a process subject to a contract of employment. A term of the agreement is that what he is paid to produce belongs to his pay-master.

"On the other hand, if an employment be general, albeit it covers a field of labor and effort in the performance of which the employee conceives the invention for which he obtained the patent, the contract is not so broadly construed as to require an assignment of the patent.

"But the manufacturing corporation which has employed a skilled workman for a stated compensation to take charge of its works and to devote his time and services to devising and making improvements in articles there manufactured, is not entitled to a conveyance of patents obtained for inventions made by him while so employed, in the absence of an express agreement to that effect."

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Mechanism Analysis

(*Continued from Page* 127)

brief space available here, it is impossible to give more than a glimpse of the Russian work and the directions in which it is proceeding.

As is natural, the Russians are dealing with all phases of the theory of mechanisms; that is, with analysis of the structure of mechanisms, their classification, synthesis, kinematics, kinetostatics, and dynamics.

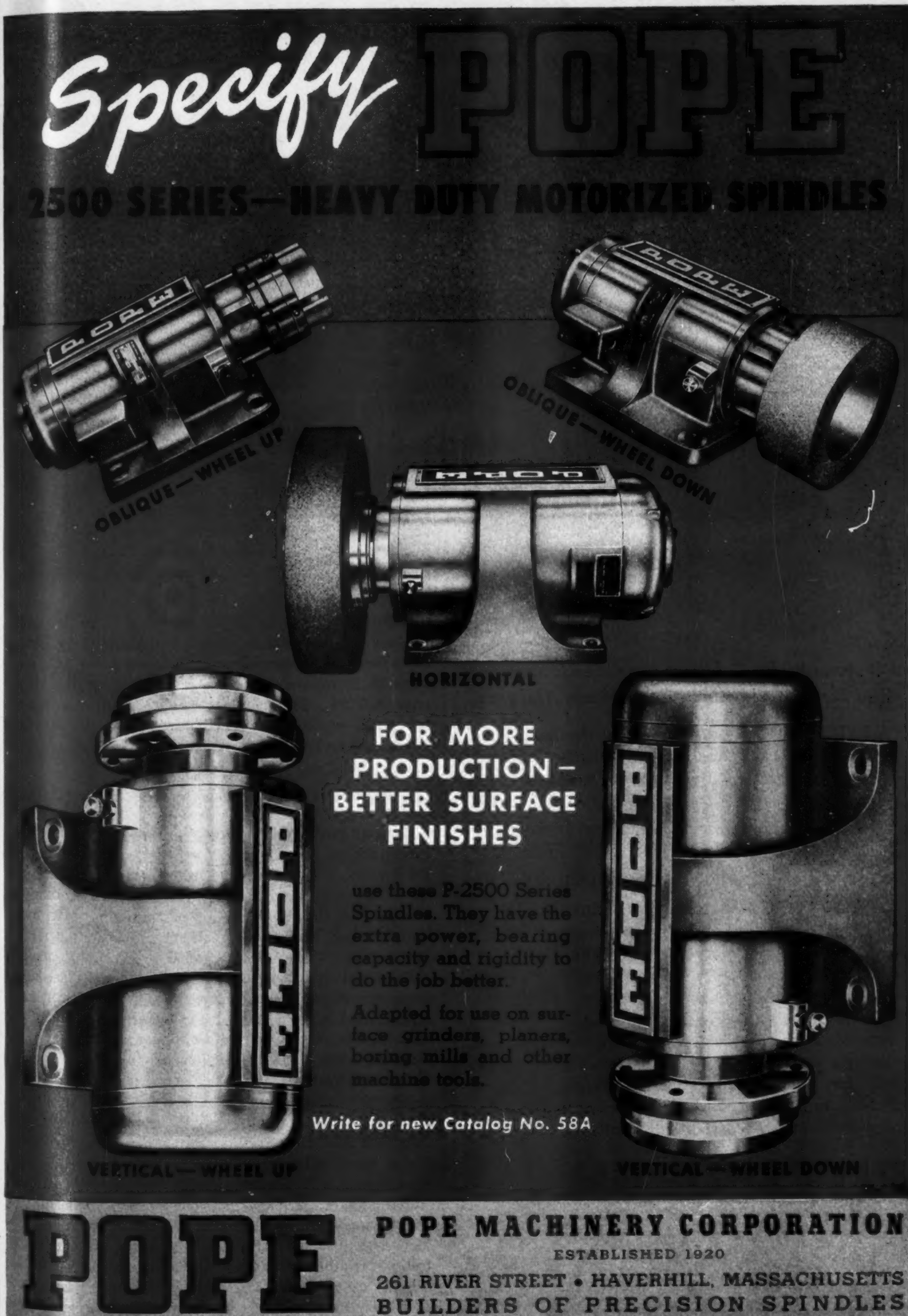
ANALYSIS OF THE STRUCTURE OF MECHANISMS: P. L. Chebychev is considered the originator of the Russian theory of mechanisms. In 1864, after Reuleaux in Germany had introduced the concepts of kinematic links and element pairs, Chebychev published in 1869 the idea of deriving a criterion for movability from the number of links and the number of element pairs in hinged mechanisms with rigid links. He gave, for this purpose, two simultaneous equations which allow the movability to be derived therefrom. Later, M. Gruebler of Germany gave a single formula as the criterion for constrained movability which is more practical and is now used almost exclusively, even in Russia. This is generally known as the "Gruebler criterion of movability," but the Russians, lately, are attempting to call it the "Chebychev criterion."

The relations by Chebychev and Gruebler apply only to plane mechanisms. A. P. Malichev is credited by the Russians with having published, in 1923, a general formula for space mechanisms. Such a formula, however, already had been given at the end of the nineteenth century by Hochmann in his book "Die Kinematik der Maschinen," about a quarter of a century earlier. Hochmann's derivation was not free from objections, but the subject was investigated again in Germany by Gruebler in 1916 and by R. Muller in 1920, who both derived the expression which is generally valid.

Early Twentieth Century Developments

Except for the methods of analysis developed by Reuleaux and his school in Germany, little new was achieved in the science of mechanisms during the latter part of the nineteenth century. At the beginning of the twentieth century, the search for new methods was pursued vigorously everywhere, but proved fruitless for some time. The first extension of this science is claimed by the Russians to be certain advances in the treatment of mechanisms with rigid links, by L. V. Assur, who published several papers from 1914 to 1918.

His method consists in developing new mechanisms from an initial mechanism by the addition of "groups of links," the type, number, and arrangement of which determine their class and order. The initial ternary links can be arranged in line, with binary links branching off from the free elements as "leads" or "ties", *Fig.* 1, by which the groups are attached to the cranks, links, or frame of an existing



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mechanism. Also, new ternary links may branch off from "internal" ternary links, *Fig.* 2. Finally, the ternary links may form closed figures or "contours" that are attached either directly or by "leads" to cranks, links, or the frame of an existing mechanism, *Fig.* 3. Rules for substituting other than ternary links, and even of binary links, are given. These groups are used not only for describing or analyzing the structure of the mechanisms, but also for purposes of classification. Ternary links in line form the first class, branched-off ternary links form the second class, and ternary links forming contour are designated as third class, groups forming two, three or more contours are designated as fourth, fifth, etc., classes. The number of binary free links by which the group is attached to an existing mechanism is called the order of that number. Moreover, the class to which a mechanism belongs also indicates the method that will help in their kinematic and dynamic investigation.

The claim to Assur's priority for this method of forming mechanisms is unjustified, as a similar method was taught in Germany by W. Lynen at Munich, from 1906 to his death in 1920. His method received publicity through the wide distribution of his lectures and notes, although a printed account of it was not published until after his death by G. Marx, his successor, in 1925, and not, as was stated in Russia, in the thirties.[3]

CLASSIFICATION OF MECHANISMS: The important problem of creating a unified and completely general classification of mechanisms has occupied the scientists in Europe ever since the beginning of this science in 1794. The first partly successful attempt was the work by Reuleaux, whose publications appeared from 1864 to 1900.

Systematic Analysis Is Advantageous

As was pointed out, Assur proposed a different attempt which is only one of several systems that may be devised. Its advantage lies in the systematic way in which one may proceed, not only in the analysis, but also in the synthesis of mechanisms. Its disadvantage lies in the fact that it is rather superficial and refers to one class of mechanisms only, namely, hinged linkages, with sliders being considered hinges with the hinge axis at infinity. On the other hand, Lynen had also dealt with mechanisms which contain higher pairs, such as cams, gears, etc. In recent Russian books, this extension has been incorporated in Assur's system.

Certain inconsistencies appeared in the course of time, as many mechanisms did not fit into this system and had to be considered exceptions. The need for a more generalized system brought forth a new idea by V. V. Dobrovolskii, who investigated the "limitations" to motions and showed that all link mechanisms can then be classified into five "families." For each of these families he gave a structural formula, the family then determining also the methodology of investigation into analysis and synthesis. I. I. Artobolevskii also worked in that direction. Assur's work covered only plane mechanisms, but the

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ideas underlying it were also used for space mechanisms by Dobrovolskii, N. G. Bruevich, and I. I. Artobolevskii.

The Russians take great pride in all this work. Nevertheless, Artobolevskii admits[3] that the important problem of creating a unified and completely general classification for all mechanisms—including electrical, hydraulic, and other mechanisms, both for existing ones and such as may be produced in the future—has not yet been solved in Russia or elsewhere in spite of the great efforts by the ablest scientists for more than a century and a half.

STRUCTURES OF COMPLETE MACHINES: So far, machines generally were considered as a succession of adjoined mechanisms. Recently, a new method of treating complete machines was published by I. I. Artobolevskii, S. I. Artobolevskii, V. A. Judin, and G. A. Shaumyan as a monograph entitled: *Method of Analysis of Automatic Machines,* Volume I. This deals with the general structural analysis of automatic machines, and presents the application of a method of analysis to a machine for cutting and rounding off dough, to a semiautomatic printing press, and to an automatic lathe.

SYNTHESIS OF MECHANISMS: The necessity of creating complex machines for the rapidly growing industry of Russia forced her scientists to attack vigorously the problem of the synthesis of mechanisms to obtain desired motions. In the last thirty years, much progress has been made in this branch, both by the Russians and by the Germans.

Synthesis may be divided into "precise synthesis" and "approximate synthesis." The German methods have been described by the author in a previous paper.[2] The Russians have developed synthesis procedures allowing the creation of desired motions with great precision. Into this section fall gear mechanisms, cam mechanisms and the like. The methods are said to have been worked out by N. I. Mertsalov, Dobrovolskii, Malychev, and others. A monograph on *Synthesis of Mechanisms* was published in 1944 by I. I. Artobolevskii, Z. Sh. Blokh, and Dobrovolskii, in the first part of which these methods are delt with. The book is available here. K. F. Ketov, N. I. Kolchin, S. V. Viakhirev, and others from the Leningrad school, and L. M. Reshetov, A. N. Kaluzhnikov, E. M. Diles, and others from the Moscow school have also worked in this field, particularly L. A. Malkin, and M. A. Kreines, the latter having established mathematical methods which allow the selection of the best mechanism desired for a given purpose.

Approximate Synthesis

The second section, approximate synthesis, has been developed in Russia along different lines than in Germany. While the Germans approximate a desired curve by passing a "coupler curve" through up to five points of the desired curve, the Russians pass one of a family of curves of known analytic equation through the given curve. In mechanisms, these curves are usually expressible in polynomials. By means of Chebychev polynomials, the maximum deviation of this curve is determined from the given

curve and the deviation minimized to obtain the least deviation from zero. The curve resulting from this procedure is a much closer approximation than is obtainable by any other method, including that of the method of least squares, and closer and much more certain than that resulting from the German method of passing a curve through five given points. This is a decided step forward. A book by N. I. Levitskii, *Synthesis of Mechanisms According to Chebychev*, is available here. This Russian method is known as the "Chebychev theory of synthesis."

The methods of precise and approximate synthesis have been used widely in the field of computing mechanisms, mostly for military purposes. N. G. Bruevich and his school have worked in this field. S. A. Gershgorin demonstrated a theorem which allows the construction of a mechanism realizing any algebraic relationship of a complex variable.

KINEMATICS OF MECHANISMS: Plane kinematics was advanced in Russia by Chebychev, P. Somov, and Assur, and their work was compounded with that of scientists from other countries. Kinematics of complex plane mechanisms, already dealt with by Assur, was extended by I. M. Rabinovich (1928) who dealt with mechanisms and static structures on even ground by analogous procedures, following a hint supplied by Assur. Bruevich developed a vector method for kinematic analysis of complex mechanisms. His work is based on Assur's classification, but is somewhat more generalized. Dobrovolskii, G. G. Baranov, I. I. Artobolevskii, and others extended it further. Cherkudinov tried to simplify the kinematics of a moving system, starting from a four-link mechanism.

Work by N. E. Kobrinskii, who investigated errors produced in mechanisms by clearances in the joints both from the aspect of their kinematics and their dynamics, is interesting. M. L. Bykhovskii's work on a method of determining velocity and acceleration errors in plane mechanisms is also valuable.

Three-Dimensional Mechanisms

One of the most difficult problems in kinematics is the investigation of three-dimensional or space mechanisms. In Russia, the work by V. N. Goryachkin, first seriously formulated in his *Agricultural Mechanisms* in which kinematics and dynamics of some space mechanisms were studied, was extended by Mertsalov who worked out methods of analysis of space mechanisms, producing some generalization in their kinematics. Most of this work concerns gears and cams in space. Because much of their published material is unavailable, Russian claims as to their predominance in this field cannot yet be verified. In their work on gears and cams they deal, however, not only with the theoretical side, but also with the kinematic processes of their practical generation. Ketov, Kolchin and others have worked in this field.

Russian scientists admit that difficult problems such as, for example, the determination of the paths of points on links of a moving "space" mechanism (so-called space coupler curves) remain unsolved.

KINETOSTATICS OF MECHANISMS: This term, which

signifies equilibrium of forces in mechanisms, has been adopted by the Russians from the Germans. The Russians claim that their treatment of mechanisms by classes or families allows them to develop relationships between their kinematics and kinetostatics, thus simplifying the solution of such problems. That relations between kinematic and kinetostatic problems exist has been known for a long time. The fact that kinetostatics, even of "plane" mechanisms, requires consideration of space problems due to the various links not actually lying in the same plane is also well-known. There seems to be little evidence that kinetostatics has been further developed in Russia than elsewhere, judging from the material available here, although such claims have been advanced.[3]

DYNAMICS OF MECHANISMS AND MACHINES: There exist so many different problems in dynamics of mechanisms that it is not possible to deal with them here. They cover, under the action of external forces, steady or stable motion, oscillations, vibrations, and control or regulation of motion.

Motion in Machines

Motion in machines under the influence of given forces were dealt with by Goryachkin, K. Roerich, Mertsalov, and others, who developed geometrical and analytical methods for that purpose. Oscillation problems form a class by themselves and appear mainly in problems of control or regulation. Vibration problems require investigation into balancing of machines. In the field of balancing machines, Akimov and others have done outstanding work. In the field of control and regulation, many Russian contributions are now available. Number 12 of the 1945 proceedings (Istvestia) of the Russian Academy of Sciences, Technical Class, deals almost exclusively with these questions.

Many problems in dynamics of mechanisms and machines have not yet been solved, as the Russians freely admit. On the other hand, they have developed electro-mechanical and other methods to measure, by experimentation, forces and deflections in the links of mechanisms or machine parts. Goryachkin, Malichev, and L. P. Smirnov have worked in the development of such general experimental methods, and N. P. Raevskii, G. L. Shnirman, and others in the development of electro-mechanical methods of measurement. Work on investigation of the motions in machines under the action of forces that are functions of various parameters, such as displacement, velocity, acceleration, and time, are said to have been started.

Apart from books available here, most of the Russian papers of importance have been published by the USSR Academy of Sciences, either in the *Reports Rendered* (Dokladi) or in the *News* (Istvestia), Technical Class. Since 1946, important papers are also published in *Work of the Seminar on Theory of Machines and Mechanisms.*

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Design Abstracts

(*Continued from Page* 168)

jigs, fixtures, patterns and machine tools that are special to the product as opposed to the general shop machine tools that may be applied to different products.

The design engineer in designing his product must take some of the responsibility for the first cost and maintenance cost of the engineering tools and even though he does not himself design the tools he must be sufficiently aware of tool design problems and costs to give these full consideration in his product design. In most companies tool design, a specialized art, is recognized as such by provision of a separate group of people who do the actual designing of tools. People with practical shop experience together with a talent for design are apt to make the best tool designers.

Planning and Cost Reduction: Planning the manufacturing line and cost-reduction activities are functions in which the design engineer must participate if the function is to be successful. The improvement in productivity is a basic element of our way of life and requires the continued diligent application of effort on the part of both manufacturing and design engineering people.

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... certain business decisions depend for their success or failure on the ability of the designing engineer

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Secondary Functions: In any workable organization it is necessary that the design engineer perform certain secondary functions. These secondary functions include the administration of the design engineering organization itself, the continual formulation and use of standards, the investigation of vendor's plants to determine a vendor's capabilities for producing components, and the testing of vendor's products.

A very important function is that of participating in the business management. Certain business decisions (such as the introduction of a new product) depend for their success or failure on the ability of the design engineer. This function is, of course, one that is only performed by a design engineer who has reached the position of assuming full responsibility for a product or product line.

RESPONSIBILITIES OF THE DESIGN ENGINEER: The responsibilities of the design engineer will depend almost

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The same economic considerations apply whether a die casting is designed for civilian or military use. For information on these considerations, ask us—or your die caster—for a copy of "Designing For Die Casting."

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entirely on his relative position in his engineering organization. For the purpose of this discussion, the broader responsibilities of the top design engineer will be outlined with the tacit understanding that an engineer working in this field may have all or only a small part of these responsibilities.

Development and Expansion of the Product Line: The majority of manufacturers, for reasons discussed previously, tend to produce one or more lines of products. It is a responsibility of the design engineer to forecast the kind of product that should be produced two to five or ten years hence.

The design engineer, in thinking ahead to predict the competitive position of his company, must, of course, seek the advice and counsel of the people who are in touch with the company's customers. In working together, however, the design engineer is the person responsible for recommending to his management the broad development program and for committing himself and his company to a heavy investment in the future.

Financial Responsibility for Quality: The design engineer is usually responsible for the quality of the product in terms of life, performance, the meetings of guarantees, and for complaint expense.

• • •

. . . the preference is for men with a thorough knowledge of fundamentals

• • •

It is readily apparent that this is a major responsibility in any large manufacturer's organization. For example, on small items such as household refrigerators, it is customary to sell the product with a five-year warranty. Because of the seriousness of potential failures, the responsible head of a design engineering organization in the General Electric Company is given the authority to stop shipment of any product if, in his judgment, the quality is unsatisfactory.

Responsibility for Manufacturing Costs: The design engineer usually does not have the direct responsibility for manufacturing costs but is indirectly responsible to the extent that his design must be capable of manufacture on a competitive basis.

Secondary Responsibilities: There are many minor or incidental responsibilities he must carry, such as those connected with the administration of a design engineering organization, the contribution to the purchasing function, the operation of test facil-

ties and laboratories, and the participation in business management.

CHARACTERISTICS AND ATTRIBUTES: The performance of the functions and the proper discharge of responsibilities discussed previously place a demand upon the design engineer for certain characteristics and attributes some of which are peculiar to his professional life while others are commonly required of most individuals in industrial organizations.

Knowledge: One of the prerequisites of a professional man is that he have mastery of some field of knowledge. At the present time both colleges and students face conflicting interests as to whether the student should equip himself with generalized or specialized knowledge.

In the larger manufacturing companies there is little doubt that the preference is for men with a thorough knowledge of fundamentals in such fields as mathematics, physics, thermodynamics, heat transfer, stress analysis, chemistry, metallurgy, etc.

• • •

. . . despite all the training opportunities available there is still a dearth of highly competent specialists

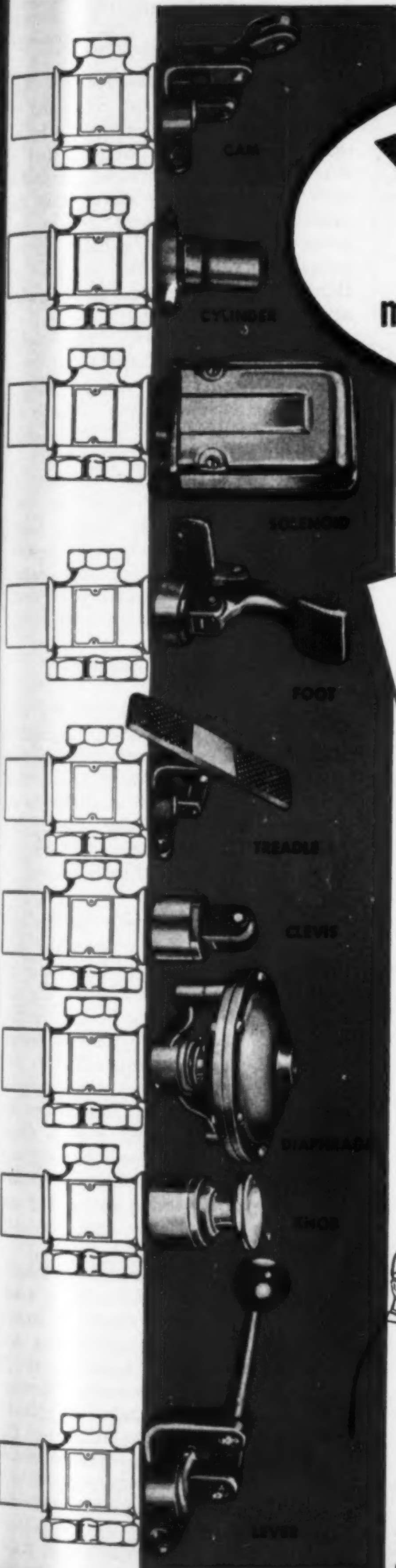
• • •

It has been the author's feeling for some time that the student's own interests are best served in the long run if he spends his first years of training in the deeper study of fundamentals rather than in the extension of more superficial specialized knowledge. After a good working knowledge of fundamentals has been acquired, it is relatively easy for the young engineer in his daily work to acquire more specialized knowledge.

It is recognized, of course, that in small companies particularly there is a fairly strong demand for young graduates having specialized knowledge in their particular field of business.

Analytical Ability: The ability to analyze problems effectively and to arrive at sound conclusions is one of the most basic attributes an engineer must possess. Perhaps one of the best tests for analytical ability is evidence of the talent for discerning the essential related facts in a mass of unrelated data and the ability to put these facts into their proper relations and to draw sound conclusions from them.

Creative Ability: Presumably it is impossible to teach a man to have creative ability. Needless to say, the development of creative ability is highly important and while the absence of creative ability will not necessarily impair a man's career, it



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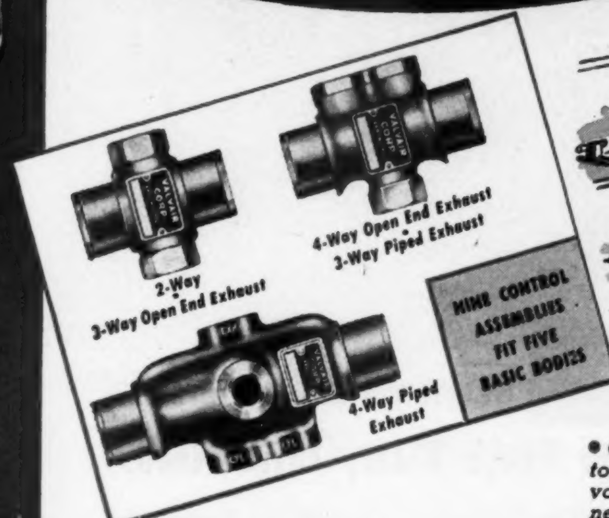

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certainly is advisable to develop whatever talents a man possesses along this line.

The Art of Communication: The importance of a fluent command of language has been emphasized by so many speakers and writers that it scarcely needs additional emphasis here. Most observers agree that the ability to think clearly and to express oneself clearly usually go together—in other words, precision of thought and precision of language are closely associated.

Other Characteristics: The design engineer should be capable of timeliness of action and should have a talent for synchronizing diverse activities and be aware of the passing of time and of the importance of time. If the design engineer wants to progress in his profession, he must have to a reasonable degree sound business sense and should have some intuitive ability to appraise values and to make a reasonably accurate appraisal of a competitive situation.

Character Is Important

He must have initiative—the ambition, drive, persistence, ingenuity, and ability to get results. Supervisory ability is another fairly broad field in which the design engineer must develop himself. Finally, as in any other walk of life, character and personality will form the keystones of any man's career.

OPPORTUNITIES IN THE DESIGN ENGINEERING FIELD: Any normally ambitious young man will be vitally interested in the opportunities for advancement in the field he is selecting for his career. In the field of design engineering (as defined in this paper) the opportunities for advancement are excellent and indeed can absorb individual talents over a much wider range than is possible in many other engineering occupations. There are three fairly broad paths, any one of which the design engineer may follow. These are:

The Technical Specialist: Despite all the training opportunities available there is still a dearth of highly competent technical specialists and a man who has the technical ability and who is willing to work and study diligently may become recognized.

The Technical Administrator: The man who assumes the final responsibility for the development of new products and for the quality and competitive adequacy of existing products is often called the Chief Engineer or he may have the title Design Engineer. In either case he is a man who has gradually assumed through the years more and more technical responsibility and in conjunction with it the administrative responsi-

bility of organizing and running the engineering division.

In this particular field a man may, at some point, find his talents limited. Or under conditions such as those existing during the depression of the '30s the opportunities may be limited. At the present time there is no limit of opportunities and practically any one who has the ability will be able to advance as rapidly as his own growth permits.

The Business and Commercial Field: The third broad path of progress is represented by the field of commercial and business activity in engineering businesses. In large companies, most men who enter the commercial field spend an apprentice period of one to three years in design becoming familiar with the company's products and with the engineering problems associated with them. During this period the candidate for commercial work will usually be taking sales training courses of various kinds and after the completion of this training period will enter one of the several fields of commercial work.

In smaller companies it is not uncommon for a man to enter the design field and later in life, when the necessary experience and judgment have been acquired, either enter the management of the business or go into business for himself. Typically, in the so-called engineering businesses such as electrical manufacturing, machine tools, and the process industries, it is the rule rather than the exception for the business managers to be men with engineering experience.

From a paper entitled "Design Engineering—a Job Description for the Guidance of Engineering Students," given at the 59th Annual Meeting of the American Society for Engineering Education, East Lansing, Mich., June 25-29, 1951.

What Industry Expects

By Roger E. Waindle

General Manager
Industrial Products Div.
Elgin National Watch Co.
Elgin, Ill.

IN ORDER to prepare myself to bring you something more than platitudes, generalities or compliments for the splendid work of you educators, I canvassed educators themselves, many business executives who employ and work with engineers, and some of the engineering societies.

There are those who claim that to graduate the highly trained technician without inculcating in him a

real appreciation of the niceties of life as brought out by a thorough knowledge of languages, literature and social science is to deprive him of the ability to enjoy life; that his "trade school" education has simply helped him to earn a living without showing him how that living may be enjoyed. My canvass of this subject leads me to the positive conclusion, supported by my own personal experience both as an engineer and as a general management man now employing engineers, that the most important educational function in preparing a man for the engineering profession is to teach him thoroughly the fundamental sciences such as mathematics, physics, chemistry, etc. As long as there are usually only four years in which to train the man, the so-called humanities must suffer. However, and this is very important, the *means* of applying this knowledge must also be supplied to the undergraduate.

Practical Education Needed

What does this mean? Am I saying we in industry want more of a "trade school" type of training than we are now getting? Yes, I am afraid so. It might appear that management is exhibiting here some of that selfishness that politicians currently so frequently ascribe to industry in their efforts to break our faith in the inherent integrity of the men who run our industries. However, that is not the case.

It is our conclusion—the firm conviction of most industrial leaders, many of whom are engineers themselves—that a good engineer becoming successful at that most important of aims, earning a living, has already learned to study. With this concept, then, our blooming, on-his-way engineer who has developed the reading habit begins to find an inclination to pick up some of the finer things in literature and the arts. And, mark you, this at a time when he wants and appreciates such things, rather than having these things literally thrown at him as a callow undergraduate whose mind was just not conditioned yet to an appreciation of the finer things of life.

Further, on this subject of undergraduate training, it is evident that the engineers have changed the face of the world in the last hundred years. It is equally evident that they didn't do this by being expert sociologists, English scholars, artists or musicians. They did what they have done by knowing their engineering. No matter what the engineer may know about human relations, the human


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ities, arts and sciences, unless he is able to carry out his engineering assignments, he will fail in his job as an engineer. What industry wants first of all in engineers is professional competence.

It seems to me that what industry expects of the trained engineers is reflected in part by the way in which industry uses the engineer.

We know, for instance, that industry uses the engineer in technical development and research where his services are principally as a technician requiring only technical training; in technical supervision where he must have technical training plus organizational and administrative ability; in promotion and distribution where technical training is essential but skill in human relationships becomes equally important; and in administration and management where technical competence is assumed but skill in human relationships and marked ability in judgment, vision and administration are most important.

Many of our manufacturing business managers today are engineers who must also deal in problems almost of a philosophical nature.

Engineering in Today's World

This brings us to the management problem of fitting machines into our modern society. It is pretty well becoming recognized that the machine is not a vicious robot but actually creates more wealth and stimulates more employment. Also, it is becoming recognized that production, and production alone, is no longer enough in our machine age. We have discovered that all the miracles of modern engineering are to little avail if they deprive a man of his dignity, ambition, skills, or sense of satisfaction in accomplishment—if they leave him with a sense of frustration or futility regarding his purpose in life.

True, industry still seeks greater production and better quality, and for these things it turns to the engineer for new machines and new processes. But industry has learned that the machines and processes are not always enough—that sometimes the potential increase in production made possible by technological progress is offset by a drop in the efficiency of the production personnel affected.

This general problem, I believe, is one of industry's greatest concerns today, and it poses a major challenge to the engineer. Earlier I characterized it as a philosophical problem, but it is actually a very practical problem in which a talent for human engineering is as important as a talent for

blueprints and tools. There are tremendous opportunities in engineering for young men who understand both the human equation and the mathematical equation, because modern industry deals with both at the same moment.

Let us emphasize, then, that depending upon the application of his basic engineering training, our engineers may find themselves emphasizing skills and abilities unfortunately never taught them in our fine engineering curricula. As you well may imagine, industry would prefer to hire engineers who know sufficient about the demands of their new position to feel confidently they can handle both the technical and social aspects of the work.

It is my feeling that the formal teaching of the sciences should be implemented by a psychologically well-thought-out method of helping the undergraduate to:

1. Derive sufficient knowledge of the "art" of engineering—the tools and methods of application—so that he can step right into industry from graduation and become a useful citizen.
2. Absorb sufficient understanding of the full scope of activity of the various types of employment for engineers so he makes fewer costly missteps in "trying to find his niche."

The real need is to develop a scientific, soundly psychological policy of gradually implanting a feeling or understanding of the business life of the technical man. In other words, educators must help the boy to select the type of work for which he is mentally and emotionally best fitted.

Technical Competence Is Primary

Let's, then, sum up the industry expectation of the trained engineer. The first requirement is technical competence; but any engineer will be very limited who does not possess:

A. Ability to think straight, logically and express himself orally and in writing
B. Mental honesty, with the ability to compromise knowingly; that is, possess judgment
C. A sense of the economic
D. A knowledge of mathematical fundamentals, rather than the ability to exercise in calculus
E. Industry, perseverance, enthusiasm, real loyalty, pleasing personality
F. Just plain "working habits"
G. Ability to get along with others
H. Imagination—vision.

From a paper entitled "What Industry Expects of the Trained En-

gineer," given at the 59th *Annual Meeting of the American Society for Engineering Education, East Lansing, Mich., June* 25-29, 1951.

Developing Creative Ability

By W. M. Simpson

Chairman, Aeronautical Engineering Dept.
University of Kansas
Lawrence, Kans.

IT IS not my intention to try to name or discuss all of the factors that may be important in the make-up of successful engineers. We would all agree that each engineer must learn certain fundamental principles and factual information that apply to his chosen field. Perhaps we could also agree that he should have a pleasant personality, good character, and many other qualities. However, if the results of our questionnaires are accepted at face value, the most important qualities to be developed in our engineering graduates are initiative in tackling new challenging technical problems, ingenuity in analyzing problems, and in using basic scientific laws, and the creative ability that designs and produces newer and better things for the world of tomorrow.

Our committee had, of course, been considering these qualities in our discussions of engineering students and graduates. However I must confess that we were surprised at the importance given to these qualities, especially to initiative and ingenuity in the results from our first questionnaire to the newer engineering teachers. These qualities were emphasized in the answers to a question concerning the "Aims of Engineering Instruction." In our second questionnaire, which went to the entire engineering staff, we asked each teacher to list the most important characteristics that must be developed in engineering students. Once again the greatest emphasis was given to initiative and ingenuity.

Goals for Practicing Engineers

If we shift our attention from the undergraduate engineer, who presumably must be bombarded with facts and figures and theories and formulas; if we shift our attention to the practicing engineer of two, or five, or ten years after graduation, we may find different goals for our engineering education. Engineering is not a static thing. We cannot hope to demonstrate or assign to our students more than a small percentage of the practical problems they may

meet during the first year after graduation, and the practical problems of the next ten or twenty years are completely beyond our capacities. Therefore our engineering education must train students to do original thinking, using fundamental principles to solve each new and different problem.

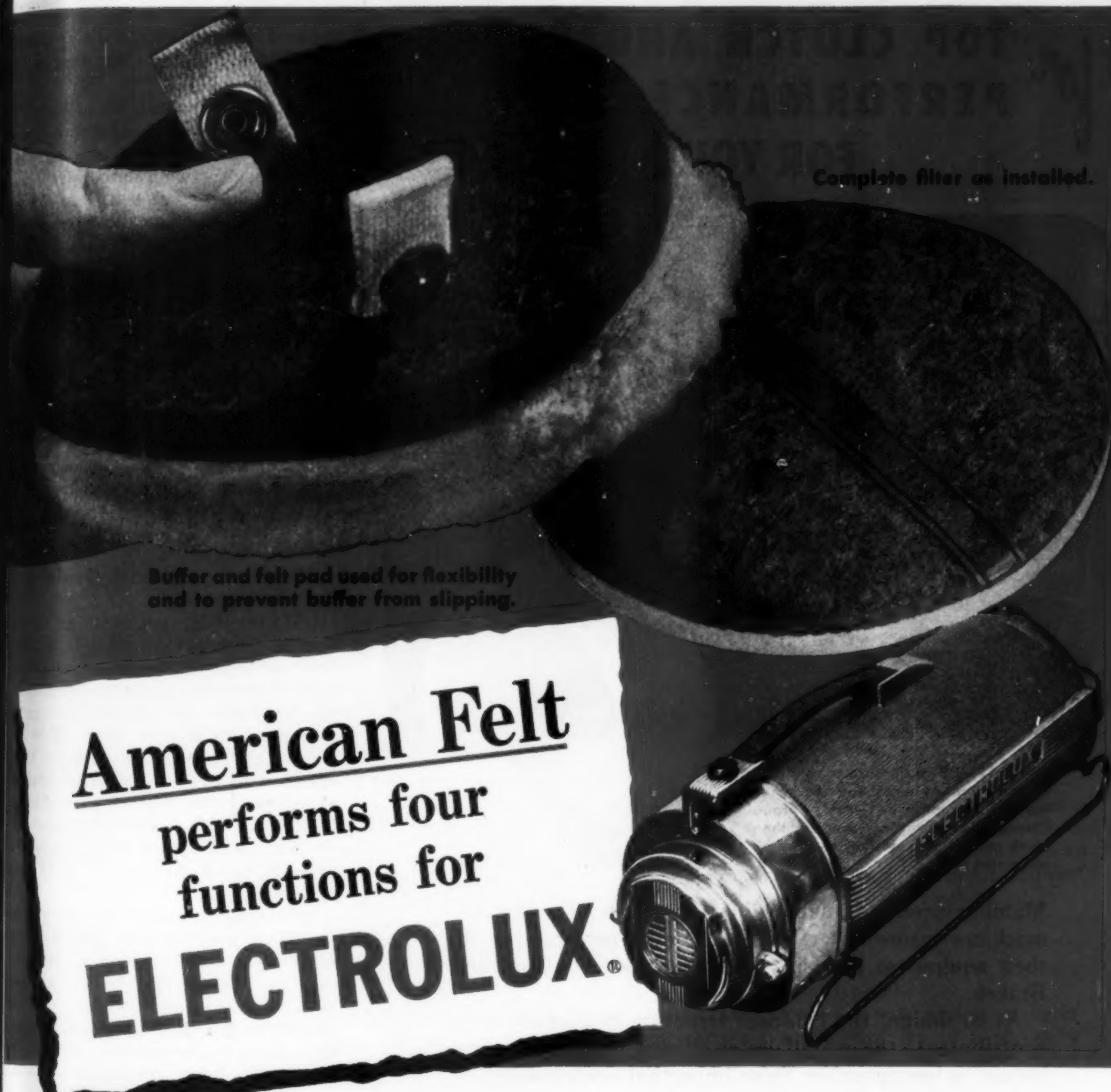
I hope we can all agree that one indispensable quality of an engineer is a thorough understanding of certain basic physical laws. These laws are the staple ingredients that must be used in the solution of any problem. If anyone would maintain that certain advanced theories are more important, it is only necessary to remind him that those advanced theories cannot be understood unless the student has a firm grasp of the fundamentals. It is true that a student without the basic understanding can often be trained to get right answers by plugging certain values in the right formulas, but we know that such a student cannot handle a new and different situation. Therefore our engineers must be trained to think in terms of fundamentals.

My wife likes to collect and try new recipes. Our kitchen is quite large enough to hold almost all of the things that she needs for most recipes, and when she wants to make an unusual recipe she merely walks a block down to the corner grocery store where they keep almost any item she wants. I think my wife is a good cook, because she is rather careful to keep on hand all of the basic ingredients that she needs, for use at a moment's notice.

Fundamental Thinking Necessary

I wish we could train our students to keep all the staple ingredients always on hand, for use at any time, as my wife keeps flour and shortening and salt. And in order to use those ingredients successfully our graduates actually must think in terms of fundamentals, rather than specialized formulas. However, it is necessary for our graduates to go a step further than my wife does when she combines materials in the kitchen. An engineer must be able to fashion his own recipe, which requires a thorough understanding of physical laws, and also initiative, ingenuity, and sometimes a great deal of creative imaginative ability.

Engineering education has had many critics. We have all heard arguments that we should stop trying to teach practical applications and concentrate on the fundamentals. I would say that we must teach practical applications in order to emphasize the fundamentals. The large majority of our students cannot understand the



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fundamental laws unless they have physical applications and physical concepts to which they can hitch their ideas.

It is true that when we seek methods for developing initiative and creative ability in our students we must consider two related problems. The first deals with the technical ability of the individual, and the second concerns his personality and character. We cannot expect a man to develop technical initiative and scientific ingenuity unless he has suitable personal qualities. He should have an enthusiastic interest in his studies, curiosity to learn more about our physical world, and a reasonable amount of aptitude and ability. In addition, our courses always should be conducted in a manner that will develop personality, self-reliance, and personal initiative.

Developing Personal Qualities

Unfortunately, engineering education does not always provide a beneficial atmosphere for the development of such personal qualities. Engineering students get little opportunity to express their own ideas. Few engineering teachers encourage their students to initiate solutions instead of following the teacher or textbook. It does not help a student's personality and initiative if he spends his time being stuffed with facts and figures.

In closing I would like to re-emphasize my belief that the development of initiative, ingenuity, and creative ability can be encouraged by giving students the best possible understanding of basic physical laws. Our best engineers will always be those who have developed initiative and ingenuity in the application of fundamental laws to physical problems.

From a paper entitled "Developing Initiative, Ingenuity and Creative Ability in Undergraduate Engineers," given at the 59th *Annual Meeting of the American Society for Engineering Education, East Lansing, Mich., June* 25-29, 1951.

Luster or Glitter?

By John A. Hannah

President
Michigan State College
East Lansing, Mich.

THE MACHINE has had to share a place with the dollar above the altar of the materialistic among us. The machine, of course, is the top-

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***110 volt AC, Motor standard but specially machined for pump mounting.**

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PUMP No. 1½ CCC

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GALLONS PER HOUR at 1725 R.P.M.		
Pressure	Pump No. 1½ CCC	Pump No. 2 CCC
0 lbs.	120 gal.	240 gal.
25 lbs.	110 gal.	220 gal.
50 lbs.	100 gal.	190 gal.
75 lbs.	95 gal.	170 gal.
100 lbs.	90 gal.	——

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INDUSTRIAL PUMP DIVISION
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ranking god, for the dollar is in a very real sense the product of the machine. But we have placed much faith in the dollar to perform tasks for us—indeed, sometimes it seems that we believe that anything can be bought with money, even peace and the love and admiration of all mankind.

But in recent years, as international tensions have persisted after the war that was to be the last great war, and as we go on building more magnificent machines to preserve a precarious margin of safety in a world seemingly bent on war, we Americans are beginning to wonder whether our faith in the machine and in the dollar has not been misplaced.

We have achieved the world's highest standard of living; we have put together the world's most stupendous industrial system; we have only six per cent of the world's population, and only seven per cent of its area, but we account for roughly half of its industrial output. But we have not bought, with all of our dollars and all of our machines, the peace and security which we Americans cherish as our greatest ambition.

Are We on the Right Track?

It is no wonder that we are beginning to question whether we are on the right track and beginning to ask whether we dare place our faith in machines, and in dollars, alone. That gnawing wonder is to blame for a great deal of the insecurity that all Americans feel these days when we see our taxes mounting, the cost of living mounting, the piles of war supplies mounting, and no peak in sight for any of them.

It is axiomatic that he who claims the credit for a particular plan or process is liable for the blame if the plan fails or the process goes awry. The unthinking folk who loudly sang the praises of the scientists for making all our wonderful gadgets possible can be quick to say the same scientists are to blame when they find that those gadgets are not all they had expected them to be. As engineers, you have had your share of the blame.

The fallacy of such thinking is obvious: the inventors and scientists and manufacturers and engineers are no more to blame for the miseries of the world than they were entitled to all of the credit when everything was going well.

Neither are the machines themselves to blame—the atom bomb is of no more importance than a grain of sand without man to direct its flight to the target and to time its detonation. The decisions lie in man, the thinking animal, not in the inanimate

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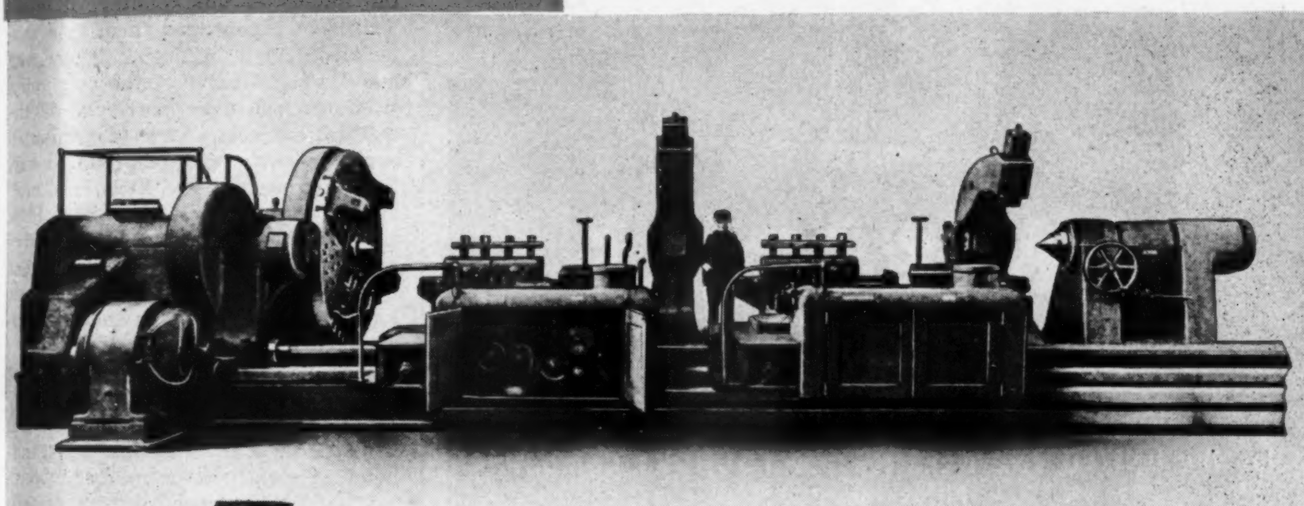
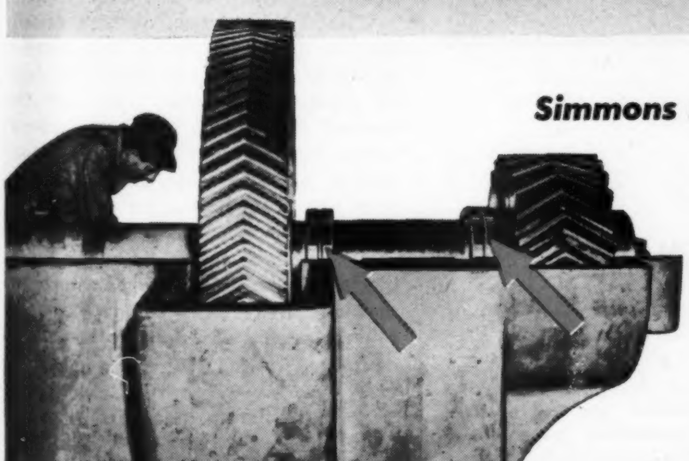
● True to its slogan "Engineered Machine Tool Rebuilding", Simmons Machine Tool Corp., Albany, N. Y., redesigned and rebuilt this giant 100" Lathe into an exceptionally quiet, smooth-running machine, with 100% increase in spindle speed. Typical engineering improvements made in the headstock, included installation of Orange Cage Type Needle Bearings in place of plain bearings; Sykes herringbone gears instead of spur gears on two final gear reductions; pressure lubrication system to all gears and bearings.





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THE 11 Orange Cage Type Needle Bearings installed on headstock shafts in place of bronze bushings, are credited by Simmons engineers with at least half of the 100% increase in spindle speed. Equally important, the Orange cage design permits some shaft misalignment between bearings without harm and prevents skewing of rollers due to uneven loading. Simmons rates Orange the most adaptable of all bearings to carry required loads within existing dimensions, when changing over from other type bearings.

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machines to which we have falsely ascribed so many human attributes. To paraphrase the famous words of Shakespeare, "The fault is not in our machines, but in ourselves—all of us."

This national malady of insecurity and its causes have great importance for those engaged in educational pursuits, perhaps more than for any other group, for we have been largely responsible for the condition. We have had as our task the training of the leaders of this country; it is we who have encouraged them in a materialistic view of life; it is we who have countenanced the stripping from the scientific curricula of the cultural subjects and have graduated engineers who, we are proud to say, knew engineering and little else, biologists who knew biology and little else, chemists who knew chemistry and little else. Is it any wonder that these poor deluded students have not known what to do with their technical knowledge?

Who is to blame if they have not been trained to estimate the likely consequences of their actions, and to judge their actions from the standpoint of social responsibility?

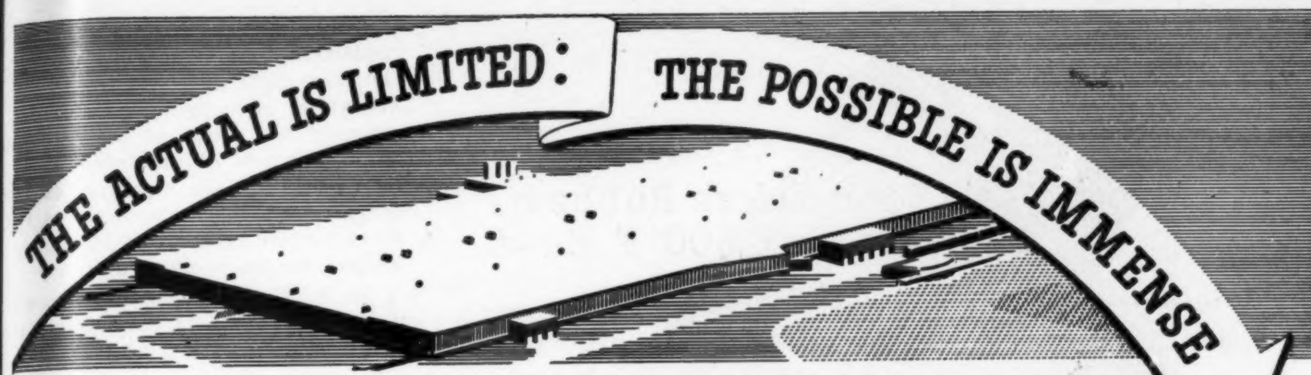
What I am advocating here for education is a revamping and revision of curricula in many fields of study to make room for some of the courses directed to training students' minds and to refreshing their inner spirits, so as to make of them whole men and women instead of technical instruments prepared to carry out their mechanical functions in making adequate livings, but failures at making lives for themselves and others with whom they come in contact.

Human Relations

It is not enough, in my opinion, to teach engineering students engineering and related subjects exclusively. They should not leave our colleges and universities with the mistaken notion that everything in life can be reduced to a mathematical formula, and their relations with their fellow men determined by sliderule calculations.

The purpose is to guarantee that we will no longer graduate music majors who know nothing of the physical and biological sciences, engineers who know little or nothing of history or art or the biological world in which they live, chemists who know nothing of the sciences in bordering fields or of the social sciences.

But while we are broadening our courses to produce graduates who can honestly claim to be educated, we must narrow them too, in order



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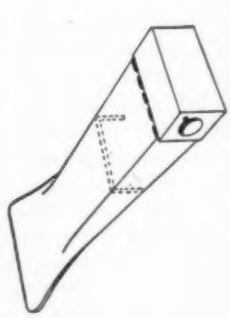

Fig. 3. Saves 51% Cost *by forming lever arm and pad as integral piece from 10 gauge metal. Weighs 2.5 pounds...costs 54¢.*

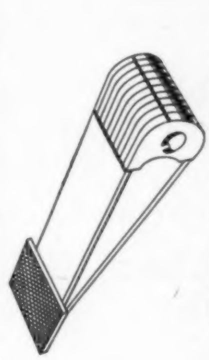

Fig. 4. Saves 67%, Eliminates Broaching. *Hub with integral key is produced by stacking stampings in assembly. Arm is 10 gauge, brake formed and welded to hub. Cost is only 31¢... weight 2.2 pounds.*

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Fig. 1. Traditional Construction. *Machine foot-lever, 10 inches long, weighs 6 pounds. Cost with broached keyway is $1.15.*

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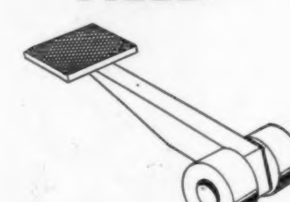

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that they may focus on some of the fundamental truths of which we have lost clear sight in recent generations. The glitter of modern civilization has obscured too much of the intrinsic value of such old-fashioned things as respect for the rights of others, respect for the persons of others, respect for the property of others, and respect for the opinions of others.

But most of all, I am sure you will agree, we must teach students to *think*. And they must learn to think, not about problems in their own spheres of activity exclusively, but about a great many other things.

Assuming Social Responsibility

Those who question whether the designer, the builder, and the operators of our machines should assume any social responsibility for the results of their actions might look with profit at the example set by such distinguished scientists as Compton, Einstein, DuBridge, and Bronk.

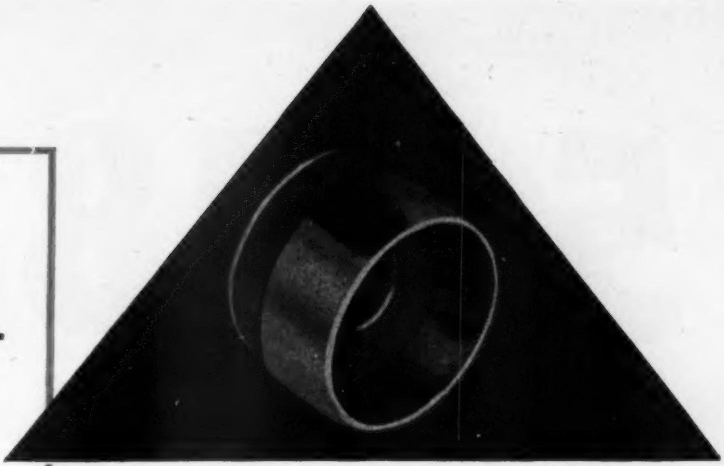
These men, who know better than any others the awful potentialities of atomic power, fully recognize the probable consequences of their creative action, and are laboring mightily to develop a social-political climate favorable to effective control of atomic energy for the benefit of mankind. And if men such as these are prepared to assume some responsibility for their actions, then it is highly appropriate that others do likewise.

In the final analysis, an educated man in a democracy is one who is trained and conditioned to be an effective citizen. He need not necessarily be a man who has attained great wealth, or professional distinction, or high public office. He may not be known far beyond the borders of his own community.

But he will have been educated to contribute to the economic stability to the limits of his creative and productive skills: he will have been educated to contribute to the social stability by his understanding of the world around him and his tolerance for the rights and opinions of others: he will have been educated to contribute to the moral stability by his acceptance and observance of the fundamental values: and he will have been educated to contribute to the political stability by his reasoned, thinking approach to political issues, his rejection of demagogic appeals, and his willingness and ability to lead or to follow, with equal intelligence.

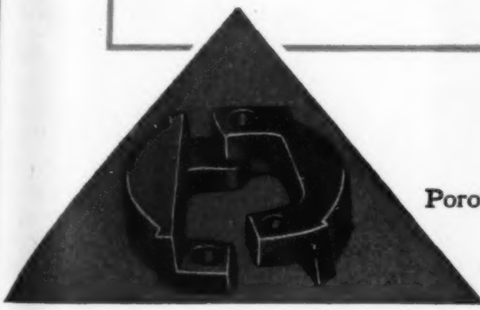
From a paper entitled "Lustre or Glitter?" given at the 59th Annual Meeting of the American Society for Engineering Education, East Lansing, Mich., June 25-29, 1951.

POWDER METAL *is good in the clutch*



This centrifugal clutch assembly for fractional horsepower motor-drives was *designed* for powder metal production.

Cup and flange offer high friction properties because of the iron-base powder metal surface.



Shoes of leaded iron give maximum relative friction.

Porous leaded bronze bushings assure self-lubrication for the life of the part.

All this . . . and low cost too! Powder metal cost is far below that of all other manufacturing methods for this part.

Often powder metal production is ideal. Often a little redesigning suits a part for the powder metal process. Then the manufacturer gets the benefit of special characteristics, high production, fine tolerances without machining . . . and low cost.

Take nothing for granted however. Talk with experts . . . for example, Stokes engineers, who make no parts, but make the presses. Stokes will guide you in design and materials, calculate your savings, or refer you to a skilled powder metal processor.

Parts illustrated were made by The Wel-Met Co., Kent, Ohio

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News

OF MANUFACTURERS

ACQUISITION of a building of 15,000 sq ft in Wapakoneta, O., has been announced by **Superior Tube Co.,** Norristown, Pa. The new plant is expected to start operations in December and will produce seamless nickel cathodes for the electronics industry.

♦

Universal Metal Products Inc. recently moved into its new plant in Wickliffe, O. The company manufactures metal parts—flat springs, wire forms, stampings, spring fasteners, split tube spacers and small assemblies, and has facilities for volume production of these parts. The new plant is equipped with punch presses and four-slide machines.

♦

A new construction and improvements program, designed to boost steel production capacity for the **Wheeling Steel Corp.,** will bring total costs of postwar expansion to more than $100,000,000. As a result of the construction and improvements program the company's annual ingot capacity has been increased by 516,000 net tons and annual capacity for buttweld pipe has been increased by 120,000 net tons.

♦

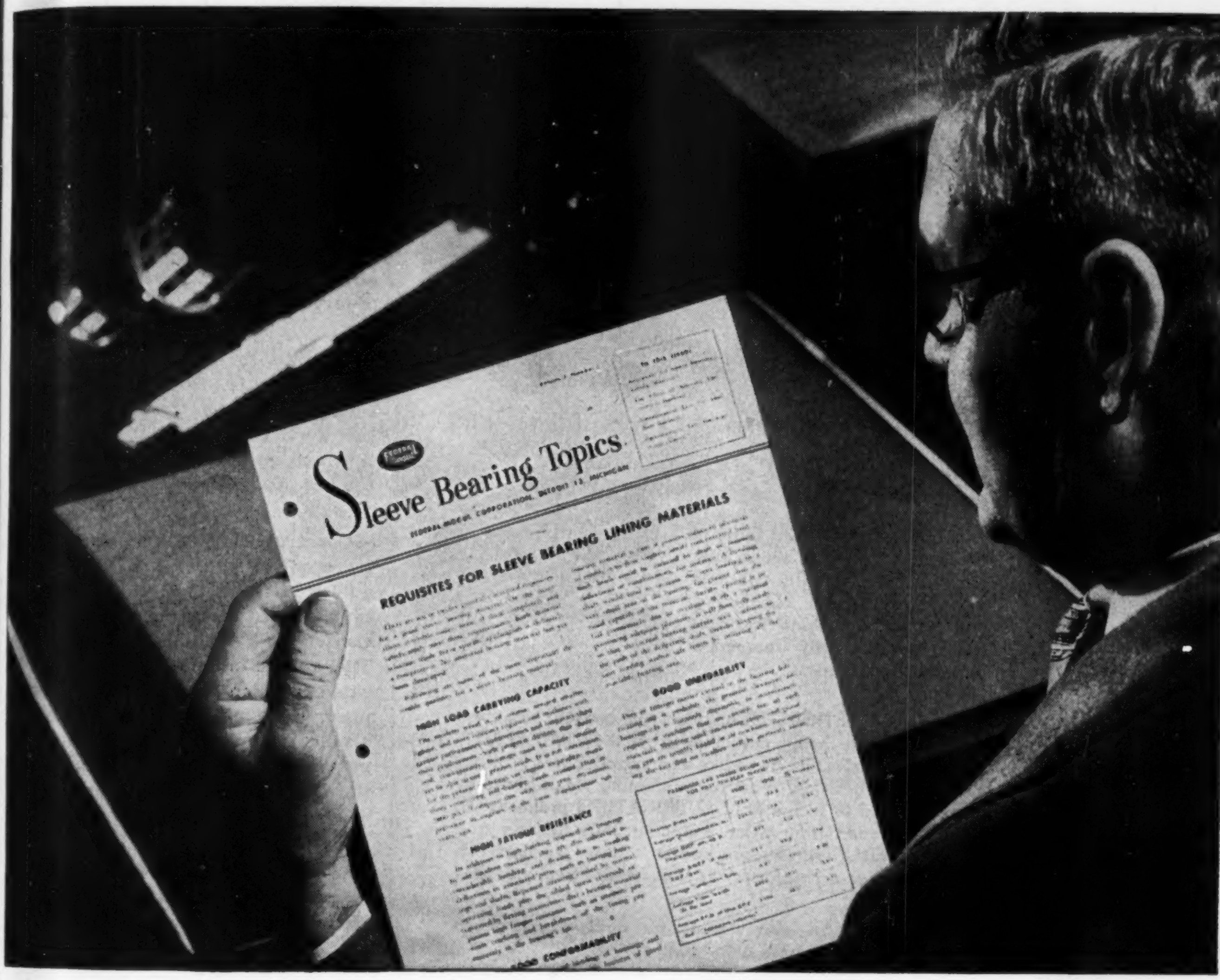
As a result of a major expansion program, production of refined nickel by **The International Nickel Co. Inc.** has been increased by 1,000,000 pounds monthly, thus achieving a goal set at the company's annual meeting last April.

♦

In expanding for military production, **Packard Motor Car Co.** plans to quadruple the size of its forge operation with the purchase of 327,000 sq ft of industrial property near its main Detroit facilities. The company has taken possession of the former R. C. Mahon Co. plant on Mt. Elliott Ave., about one-half mile north of the present Packard forge shop.

♦

Wyman-Gordon Co. has announced an expansion program for its North Grafton, Mass., press forging plant. The present press building will have an addition of approximately 185,000 sq ft, and new buildings will include one of about 500,000 sq ft to house the processing operations, mainte-



Sleeve Bearing Topics
FEDERAL-MOGUL CORPORATION, DETROIT 13, MICHIGAN
REQUISITES FOR SLEEVE BEARING LINING MATERIALS
HIGH LOAD CARRYING CAPACITY
GOOD EMBEDABILITY
HIGH FATIGUE RESISTANCE

nance equipment and diesinking facilities. Office, laboratory, engineering and power facilities will also be installed. The expansion program includes installation of two new die-forging presses, one of 50,000 and the other of 75,000 ton capacity. These additional facilities are made necessary by the increased aircraft program and by the current trend in aircraft construction toward the use of larger forgings.

♦

A long-term contract to build large naval aviation rocket motors has been awarded by the U. S. Navy to the **York Corp.** Initial work on the contract is expected to begin before the end of this year.

♦

Construction has begun on an integrated mass production plant for guided missiles, a U. S. Navy facility to be operated at Pomona, Calif., by **Consolidated Vultee Aircraft Corp.** The guided missile division, now located at San Diego, will supervise plant construction, operate the government-owned factory and build supersonic interceptor-type missiles for the Navy's Bureau of Ordnance.

♦

The general offices and plant of **The A. H. Emery Co.** have been moved to a new building on Pine St., New Canaan, Conn.

♦

A new $5,000,000 industrial belting plant has been completed by **B. F. Goodrich** in Akron, O., and is now in full operation. One of the largest facilities of its kind, this plant will enable the company to meet the demand for larger conveyor belts to make higher lifts and to handle heavier loads and harder impacts. Conveyor belting can now be produced in single rolls up to 35 tons in weight.

♦

Construction of a new plant near Kansas City, Mo., for **Fairbanks, Morse & Co.** has been started. It will contain approximately 500,000 sq ft of floor space, which includes a foundry, and is to be used to make engines and pumps.

♦

Members of the Plastic Technical Council of the plastics division, **Monsanto Chemical Co.,** recently celebrated their fifth anniversary as members of a pool of knowledge for manufacturers with plastics problems. The ten-man council, representing a total experience of more than a century in the plastics business, was established to provide expert assistance on plastics application. Problems are placed before

the council for discussion and research, and the council's findings are set forth in a written recommendation containing any helpful and relevant comments that may evolve from the discussion.

♦

The plastics mold-making facilities of the **General Electric Co.** have been expanded and modernized as an integration of mold-making operations to service the Decatur, Ill., and Taunton, Mass., molding plants of the division. The modernized tool room, located in Pittsfield, will cover 40,800 sq ft, twice the area of the former mold-making operation. Similar machine tools are grouped together for efficient supervision of activity, and machinery capable of tooling large molds has been installed in anticipation of the trend for larger plastics moldings.

♦

Burroughs Adding Machine Co. recently acquired **Control Instrument Co. Inc.,** Brooklyn, N. Y. Designer and manufacturer of electronic instruments and fire control devices for the U. S. Navy, the latter company will continue, as a separate corporation, to use its facilities for defense production in this field.

♦

To prevent confusion between the name Electro Machines Inc. and several similar firm names, and to better identify name with product, the manufacturer of Doerr electric motors has officially changed the company name to **Doerr Electric Corp.**

♦

Quaker Rubber Corp., division of **H. K. Porter Co. Inc.,** has begun a quarter million dollar expansion of its hose manufacturing facilities to produce high pressure wire braided hose for the Air Force. The entire sum will be spent for special manufacturing equipment necessary for the production of this high pressure hydraulic control hose.

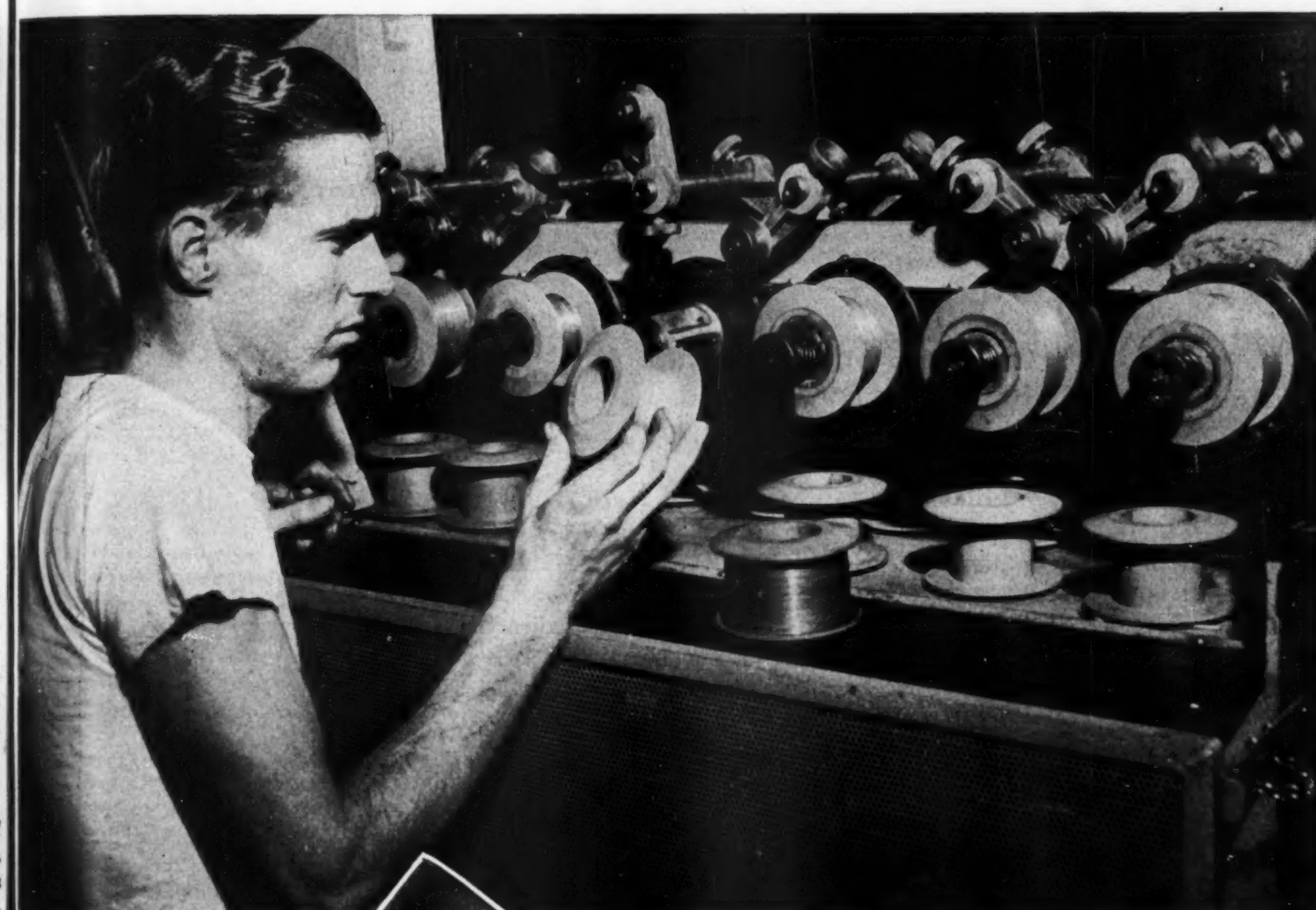
♦

Scheduled for completion by September, a one-story building which covers 150,000 sq ft is being built at Tupelo, Miss., by the **Rockwell Mfg. Co.,** Pittsburgh.

♦

A new aluminum smelting plant, the first to use lignite for fuel, will be built by the **Aluminum Company of America.** The plant, which will have a production capacity of 85,000 tons of aluminum annually when completed, will be located approximately 60 miles south of Waco, Tex. Production is expected to start in

What's U.S. Rubber doing to prevent spool breakage?



The spools on this wire coating machine are made of Uscolite, U.S. Rubber's new plastic. They can deform under loads without breaking to a greater extent than metals can.

This Uscolite pipe was only dented after being hit by a .44 calibre revolver bullet fired from 20 yards. This amazing plastic is light in weight, extremely versatile.

● "U.S." makes spools of Uscolite, a remarkable plastic which is replacing many other materials, including other plastics. These spools do not chip and get rough around the edges, as do metal spools. Uscolite spools have low thermal conductivity hence wire spooled when hot stays tight upon cooling. A wide variety of products are made of Uscolite, including many types of piping. This great material is resistant to most chemicals, has high impact strength, is furnished in standard lengths; pipe can be cut to size and threaded on the job. For more information write to address below. In Canada, write to Dominion Rubber Company, Montreal.

UNITED STATES RUBBER COMPANY

MECHANICAL GOODS DIVISION • ROCKEFELLER CENTER, NEW YORK 20, N. Y.

the early fall of 1952. The company previously had placed in operation a gas-fueled aluminum reduction plant at Point Comfort, Tex. This plant is being enlarged to produce an additional 35,000 tons annually. Also under construction is a new 85,000-ton smelting plant at Wenatchee, Wash., and a new plant at Bauxite, Ark., for the refining of bauxite ore into alumina.

♦

An electric resistance-weld tube mill with a capacity for making line pipe and casing in sizes from 4½ up to 16 in. OD, in thicknesses ranging up to 9/16-in., is being built for the **Lone Star Steel Co.,** Dallas, Tex.

♦

Through the installation of a Yoder forming machine, the San Francisco plant of **Clingan and Fortier Inc.** is now able to produce continuous rolled form sections to meet many specification requirements. The company can either supply the raw material or produce shapes from the customer's own stock. The 12-stage machine will provide special aluminum or steel shapes to fit almost any pattern.

♦

Heli-Coil Corp. has moved into its new plant at Danbury, Conn. In addition to the manufacturing area, the new structure will also house the firm's executive, administrative and sales offices and its engineering and product development departments.

♦

Approximately one-fifth of the total production of **Hotpoint Inc.** will be devoted to defense work in 1952. Two new factories in Chicago that will provide a million sq ft of manufacturing area are nearing completion, and this combined facility will be entirely devoted to the production of jet engine components. In addition, the company is building an additional plant in Milwaukee where turbo superchargers will be built.

♦

Construction of a new plant in Concord, Mass., has been started by the **General Radio Co.,** manufacturer of electronic products. The new plant will be a three-story building of 72,000 sq ft.

♦

Celanese Corp. of America has started construction of a large paraformaldehyde plant to be erected on the same site as the present chemical plant at Bishop, Tex. This new expansion will increase the output of paraformaldehyde in the United States several fold and will help to

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FASTER, more convenient, and more economical assembly line operations are possible with Hyatt Hy-Load Roller Bearings because their component parts are freely interchangeable.

Separate bearing elements can be assembled on shafts and in housings at different locations. There is no need to mark or tag matching components because the separate parts can be brought together on the assembly line with complete assurance of their perfect mating. Surely, this feature of Hyatt Hy-Loads makes possible more efficient production planning and layout.

* * *

Interchangeability of component parts is just one advantage of the Hyatt Hy-Load line of cylindrical roller bearings. For complete information write for catalog 547. We'll be glad to send one to you. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

alleviate the shortage of a critical defense raw material. This chemical is used in plastic electrical parts for condensers, transformers, etc., and in resins for heavy duty brake linings for tanks and similar military equipment.

•

Graham S. McCloy, engineer in the **Westinghouse Electric Corporation's** appliance division, Springfield, Mass., plant, received $5000 as a special award for outstanding achievement in his invention of the first fully-automatic defrosting refrigerator. The award is part of a Westinghouse program designed to reward outstanding company inventors.

•

Electro-Seal Corp., Des Plaines, Ill., is now located in a new plant at 946 North Ave. The new structure provides more than three times the plant capacity of the former quarters.

•

Upon his retirement, W. F. Hurlburt Sr., chairman of the board of **Automatic Switch Co.,** Orange, N. J., was presented a testimonial plaque by the employees of the company. Mr. Hurlburt had been president of the company from 1929 until the end of last year, when his son took over this responsibility.

•

The **C. Lee Cook Manufacturing Co. Inc.,** Louisville, has announced plans for expanding its production facilities to meet demand for its metallic rod packings and graphitic iron piston rings. Capacity will be increased approximately 50 per cent.

•

A $43,000,000 expansion and modernization of steel operations in the Rouge plant of **Ford Motor Co.** will add 190,000 tons of finished steel capacity annually for defense and civilian use. The program, to be completed by spring of 1953, will increase the total output of finished steel by about 18 per cent. Scheduled are 37 new coke ovens, a new sinter plant, installation of new pig casting equipment and extensive improvements in the open hearth and rolling mill facilities.

•

The first large-scale, self-contained plant for titanium metal production will be constructed at Henderson, Nev., by **Titanium Metals Corp. of America,** a company owned jointly by **National Lead Co.** and **Allegheny Ludlum Steel Corp.** The project will increase world production of titanium by 800 per cent. Terms of the contract with the Government call for

ELIMINATE MOTOR FAILURE with class (H) insulation made with DOW CORNING SILICONES

Wet Motors are a constant threat to your production schedules . . . unless they're wound with Dow Corning Silicone (Class H) insulation.

Here's evidence of the fact that Class H has at least 10 times the wet insulation resistance of the next best class of insulating materials. At Virginia-Carolina Chemical Corporation's Homewood mine, a 300 hp., silicone insulated motor was back in service 3 hours after flooding with mud and waste water. Under the same conditions, an identical Class B motor had to be reworked and rebaked. Similar experience over the past 5 years has persuaded many chemical companies to specify Class H exclusively for all condensate and centrifugal pump motors.

Hot Motors die young . . . unless they're protected with Dow Corning Silicone (Class H) insulation.

Here's evidence of the fact that Class H insulation makes hot and hard working motors last 10 times longer than they ever did before. Silicone insulated spinner bucket motors in rayon mills last 6 to 24 times as long as Class A motors. Silicone insulation makes the high speed, rapidly reversing motors used by Cogsdill Twist Drill Company last 12 to 100 times as long as Class A or Class B motors. In a large steel mill, a crane hoist motor had 4 to 42 times the life of a Class B motor.

Note to electrical Design Engineers

There's a rapidly growing industrial and military demand for Class H equipment . . . the only kind that can withstand the toughest operating conditions. Write for Catalog No. P-9, listing Class H insulation components and specifications.

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an initial production of 3600 tons of titanium per year, and operations are expected to reach this level by late 1952. Operations will include the production of titanium sponge and the melting of the metal into ingots.

♦

Barnes - Gibson - Raymond division of **Associated Spring Corp.** has moved to a new and larger plant at 40300 Plymouth Rd., Plymouth, Mich. With twice the productive capacity, the new factory takes over the operations of the company's former Detroit plant.

♦

In order to identify the company name more closely with its products, the Operadio Manufacturing Co. has changed its name to **Dukane Corp.** The firm is engaged in the production of highly specialized electronic defense material and owns and operates two plants, both of which are located in St. Charles, Ill.

♦

The offices and factory of the **Cords Ltd.** division of the **Essex Wire Corp.** have been moved to DeKalb, Ill., from Newark, N. J.

♦

Because of expanding operations, **Industrial Plastics Co.** has moved to a larger plant at 1829 South 55th Ave., Chicago 50, Ill. The modern new plant has over 30,000 sq ft of actual production area on one floor that is devoted to compression, plunger transfer and injection molding, as well as mold making, finishing, painting and hot stamping.

♦

The Groov-Pin Corp., formerly of Union City, N. J., recently moved into its new plant and general offices at 1119-1133 Hendricks Causeway, Ridgefield, N. J. The new building provides 40,000 sq ft of space, an increase of about 40 per cent. Included are separate facilities for manufacturing Tap-Lok inserts, a new self-tapping threaded bushing designed as a foundation for tapped threads in aluminum, magnesium, plastics, and other materials softer than steel.

♦

The National Production Authority has granted the **Whitney Chain Co.** of Hartford, Conn., a certificate of necessity to expand its manufacturing capacity. Construction of the new plant, to be located in Longview, Tex., will enable the company to be nearer its petroleum, mining and agricultural markets. Expansion of facilities in the company's Hartford plant is also under way.

NATIONAL OIL SEAL LOGBOOK

Reprints from this or other Logbook pages are available for your files. Request them from our Redwood City, California office

Where Pressure Lubricating Systems are Employed— Dependable Oil Seal Performance is a Must

Many machinery manufacturers are adopting pressure lubricating systems in their new designs. This method of lubrication insures longer trouble-free performance, reduces maintenance costs and eliminates shut-down time ordinarily required for periodic manual greasing.

The new Emsco "GB-800" oil field drilling rig is a fine example of heavy equipment which employs pressure lubrication. In this new unit more than 25 oil seals are employed on shafts ranging in size from 1½ to 10 inches. As shown in the photo of the drawworks (Fig. 1), three engines, transmission and hoist are mounted on a common skid and can be transported as a unit. The cut-away drawing (Fig. 2) is of the main hoist drum shaft assembly. The pressure lubricating system is piped to bearings on the main shaft and in the idler sprocket. Oil flows through the bearing assembly flushing out all dirt or other foreign matter.

In this drum shaft section, five single-lip, spring-loaded National 50,000 series seals (Fig. 3) are employed. Near the clutch position (A) two of these seals are mounted in tandem to provide protection against leakage into the clutch. The lubricating system places the relatively large oil seals under a constant internal pressure. The equipment is also subjected to frequent reversing and heavy load shocks resulting in a strenuous heavy duty sealing problem.

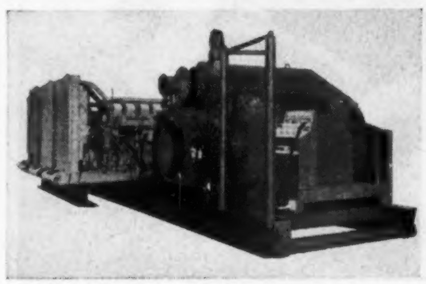
Fig. 1—New Emsco "GB-800" skid-mounted rig for portable derrick operation

National leather sealing members are specially treated to retain their shape and maintain an effective seal when subjected to such extraordinary operating conditions. These same type National leather seals have established performance records in many heavy duty applications on shafts up to three feet in diameter.

If you are working on a design for heavy duty equipment, remember: National Oil Seals are, daily, establishing performance records. The seals you need are probably listed among National standard designs already in production for you. Investigate and see for yourself. No cost or obligation, of course.

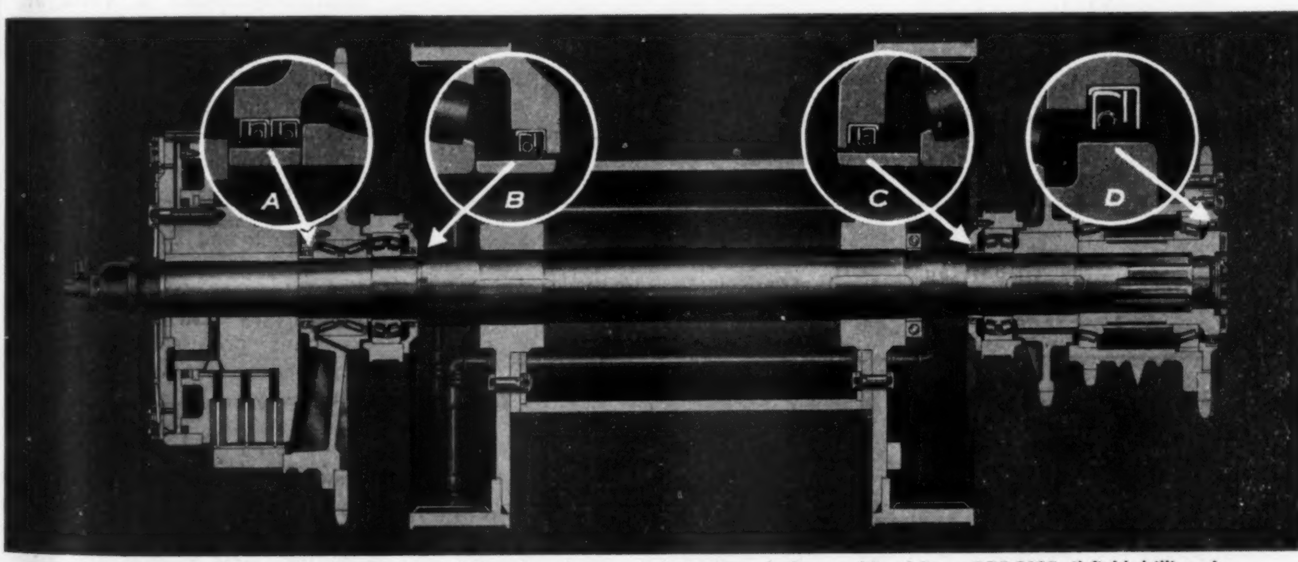

Fig. 2—Cut-away drawing showing position of five oil seals on main hoist drum shaft assembly of Emsco "GB-800" oil field drilling rig

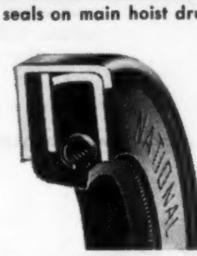

Fig. 3—National 50,000 series leather oil seal

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DOWNEY (Los Angeles Co.), CALIF. . *11634 Patten Rd., Topaz 2-8166*
MILWAUKEE, WIS. . . *647 West Virginia Street, Broadway 1-3234*
NEW YORK CITY, N. Y. . . *122 East 42nd Street, Lexington 2-8260*
PHILADELPHIA, PA. . . *401 North Broad Street, Bell-Walnut 2-6997*
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Society

ACTIVITIES

THE 1951 Fall Meeting of **The American Society of Mechanical Engineers** will be held at the Hotel Radisson, Minneapolis, September 26-28. The program will include 23 technical sessions at which 49 papers will be presented. The Machine Design division is sponsoring two technical sessions on Thursday, September 27. At 9:30 these papers will be presented:

"Characteristics of Dished-Plate (Belleville) Springs as Measured in Portable Recording Tensiometers," by James J. Ryan, professor of mechanical engineering, University of Minnesota. "The Theory of Long-Deflection Constant Force Spring Elements," by Frank A. Votta, Jr., design engineer, Hunter Spring Co.

At the 2:30 p.m. session, co-sponsored by the Machine Design and Petroleum divisions, the papers to be presented are:

"Serviceability of Paper-Machine Lubricants," by M. L. Langworth and Bruce Weetman, Texas Co. "The Machine-Tool Laboratory at the University of Illinois," by Lawrence E. Doyle, assistant professor, mechanical engineering, and W. C. Deem, Jr., University of Illinois.

♦

New Chapters of the **American Society of Tool Engineers** have been chartered at Los Alamos and at Albuquerque, New Mexico. The Alamos Chapter will be the 92nd Chapter and the Albuquerque Chapter the 93rd chartered by the ASTE in major industrial sections of the United States and Canada.

♦

Significant expansion of its technical research program is being undertaken by **Alloy Casting Institute** to help meet defense mobilization needs and other engineering and equipment requirements dependent on the use of stainless steel castings. Three new projects closely keyed to current production and supply problems of the industry and its customers are being instituted at major research laboratories. Because of the demand for high alloy castings and the concurrent shortages of alloying elements, the ACI Technical Research Committee is concentrating its alloy conser-

vation studies at Battelle Memorial Institute on the high temperature properties of the 21 per cent chromium, 10 per cent nickel type alloy. Development of titanium-stabilized corrosion resistant castings, important for use in expanding aircraft production, is being made the subject of an accelerated investigation to be carried out at Ohio State University. An extensive study of improved gating systems for high alloy casting production will be conducted as part of the ACI program under way at Massachusetts Institute of Technology, under auspices of the Shop Practice Committee of ACI.

♦

A total attendance of 2277 persons marked a new high for the **American Society for Testing Materials** at the 1951 Annual Meeting at Atlantic City. Sixty-two of the Society's technical committees reported at the meeting, with the result that 57 new specifications and tests were approved and revisions in over 200 existing tentatives and standards were acted on. About 75 specifications and tests that have been published previously as tentative were approved for reference to Society letter ballot for adoption as standard. All of these new and revised specifications will be published later in the 1951 Supplement to the Book of ASTM Standards.

♦

The Society of Plastics Engineers, Inc., 409 Security Bank Building, Athens, Ohio, is offering a prize of $50.00 to the individual submitting a design for the SPE membership lapel pin considered by the board of judges to be the best and at the same time suitable for fabrication from a plastics material. Deadline for the contest entries is November 1, 1951.

♦

Ervin George Bailey, past president of **The American Society of Mechanical Engineers** and vice president of Babcock-Wilcox Co. has been awarded the 1952 John Fritz Medal and Certificate "for outstanding engineering achievements in the field of combustion and distinguished service to his fellows in advancing the engineering profession." The John Fritz Medal, often referred to as "the highest award in engineering," is perpetuated by the four leading engineering professional societies: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers and American Institute of Electrical Engineers as a joint honor for scientific or industrial achievement in any field of pure or applied science.

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SALES AND SERVICE

Personnel

SEVERAL promotions were announced recently in the sales department of The Carpenter Steel Co. at its plant in Reading, Pa. **Wallace M. Loos,** associated with the company since 1928, has assumed new responsibilities as manager of mill products. Succeeding Mr. Loos as manager of stainless steel sales, **Harold A. Brossman** has relinquished his duties as manager of alloy steel sales to **Howard M. Goodman.** Mr. Goodman was previously assistant manager of stainless steel sales and is replaced in that position by **Robert F. Koch.**

♦

The United Manufacturing Co., Bedford, O., recently appointed **Joseph N. Ryder** to the post of sales manager. Affiliated with the company for a year, he will now supervise the sale and distribution of all products. Mr. Ryder formerly held the positions of sales representative for the Consolidated Iron and Steel Corp., eastern sales manager for the Pittsburgh Valve Corp., and sales manager for the Arizona Engineering Corp.

♦

William V. O'Brien, a commercial vice president of General Electric Co., has been appointed manager of the firm's apparatus marketing division. He will be located at company headquarters in Schenectady, N. Y. Mr. O'Brien joined the company in 1922 and has served in various sales engineering capacities since that time.

♦

Separate organizations to handle the manufacturing and sales of acetate rayon and Orlon acrylic fiber have been established in the acetate division of E. I. du Pont de Nemours and Co. Inc. **Thomas H. Urmston,** assistant manager of the division, will continue in charge of acetate rayon operations, and **J. N. Tilley,** recently made an assistant manager of the division, will head the activities for Orlon. **Henry C. Froehling,** an assistant director of sales, becomes director of sales for acetate rayon; **George S. Demme** continues as director of sales for Orlon; and **Leonard A. Yerkes Jr.** will continue as assistant director of sales for Orlon. **W. E. R. Straughn** is now assistant director of sales for acetate rayon. The

company also recently announced the appointment of **A. J. Smith Jr.** as assistant director of sales for Dacron polyester fiber.

♦

Edgar T. Gregory has been named manager of flat belting sales and has been succeeded as operating manager of the industrial products sales department of The B. F. Goodrich Co. by **Donald E. Schlemmer.** Concurrently, the company announced the appointment of **Robert Price** as sales manager of the plastic products division, with headquarters in Marietta, O.

♦

Handy & Harman has announced that **M. W. Townsend** has assumed the direction of sales for the company, including products used in the industrial field. He has served for five years as assistant to the vice president in charge of sales. His headquarters will be at the company's general offices in New York.

♦

To cover the northern California territory, **Howard J. Dauphinee** has been appointed to Jenkins Bros. valve sales staff. He will work out of the company's San Francisco office.

♦

Robert R. Simons has been elected vice president of the Sharonsteel Products Co. of Pennsylvania, a warehouse subsidiary of the Sharon Steel Corp., Sharon, Pa. He succeeds **T. J. Moore Jr.,** who will devote his entire time to the Brainard Steel Co. of Warren, O., also a subsidiary of Sharon Steel. Mr. Simons acquired experience in the Detroit district sales office and Sharonsteel Products of Michigan and has been manager of Sharonsteel Products of Pennsylvania for the past year and a half.

♦

Three new appointments were announced recently by Warner Electric Brake & Clutch Co., Beloit, Wis. **Elton Miottel,** appointed field engineer, will have his offices in Milwaukee and will operate throughout the Wisconsin area. His chief duties will be concerned with the application of electric brakes and clutches on various types of industrial machines. **Roger H. Brown** was named eastern district manager. Formerly in charge of operations in New York, Philadelphia and Washington, D. C., he also will cover the New England states and upper New York. Heretofore field engineer in Wisconsin, northern Illinois and Iowa, **R. F. Edgar** has been made mid-

western district manager of the company's industrial division, which includes the territory of Illinois, Wisconsin, Missouri, Kansas, Nebraska, North and South Dakota, Minnesota, Iowa and Michigan.

♦

To be located in Worcester, Mass., **Ewalt Maurushat** has been appointed sales engineer for the New England district of Hyatt bearings division, General Motors Corp. Mr. Maurushat has been with the division since 1937 and spent eight years in the engineering department before transferring to sales. He replaces **Frank U. Naughton Jr.**, who has become manager of Hyatt's eastern sales division at the company headquarters in Harrison, N. J.

♦

Charles A. Macfie and **J. Aylmer Doucett,** who are responsible for general sales policies, sales, and customer relations for copper and copper alloy mill products of Revere Copper and Brass Inc., have been elected to the company's board of directors.

♦

The appointment of **Robert F. Hodgson** as sales manager has been announced by Hydraulic Equipment Co., Cleveland. Mr. Hodgson has been associated with the company since 1945, serving in various capacities in both sales and engineering. In addition to his new duties he will continue as chief engineer.

♦

E. A. Freiburger has been named general sales manager of the coating division of Irvington Varnish and Insulator Co., Irvington, N. J. He will be in charge of all sales activities for the division, with the exception of cable insulation sales. **Jean H. Rooney** has been promoted to sales service manager to succeed Mr. Freiburger, and **James D. Smith** has been named varnish sales manager.

♦

Lincoln Engineering Co., St. Louis, manufacturer of lubrication equipment, has appointed **John E. Renner** to the position of general sales manager. He will direct sales of the company's automotive, agricultural and industrial divisions.

♦

A. H. Borchardt has been elected a vice president of Worthington Pump and Machinery Corp., Harrison, N. J. He will have overall responsibility for the sale of the corporation's entire line of pumping equipment, including centrifugal, reciprocating and vertical turbine pumps. Succeeding Mr. Borchardt, **V. de P. Gerbereux** has been

appointed manager of the centrifugal pump sales division. Other new appointments made recently by Worthington include that of **Herbert E. Gallison** as manager of the industrial mixer sales division with headquarters at the Dunellen, N. J., plant, and **W. Clifford Mumford** as manager and **Fenmore E. Dunn** as assistant manager of the vertical turbine pump sales division. **Herman H. Miller**, who plans to retire at the end of this year, has relinquished the managership of the compressor division to act as consultant to his successor, **E. A. Murray.**

•

Formerly a sales representative in the Cleveland district, **Frank J. Byrne** has been appointed assistant manager of sales for the steel strapping division of Brainard Steel Co., Warren, O. He previously served in sales capacities with Allegheny Steel Band Co., Cleveland Tractor Co., Cletrac-Wisconsin Sales Co. and Curtis 1000 Inc.

•

Carleton Ellis Jr. has been appointed director of sales for Plaskon division, Libbey-Owens-Ford Glass Co., Toledo, O. Mr. Ellis has been with the division for 18 years and has 20 years' experience in the synthetic resin field. He has served as zone manager of the Chicago sales office; manager of the new products division; Washington, D. C., representative during World War II; director of purchases; and since September, 1950, manager of coating resin operations. As director of sales he will be responsible for sales and promotional activities on all products.

•

The hydraulic machinery division of The Watson-Stillman Co., Roselle, N. J., has announced the appointment of **H. L. Henry** as divisional sales representative of northern Ohio. Previously representing the company in western New York State, Mr. Henry will carry out his new assignment from his headquarters in Akron.

•

In line with the national defense program, Minneapolis-Honeywell Regulator Co. has added 33 new sales engineers to 23 strategic defense areas throughout the country. Having recently completed a course in industrial instrument maintenance and repair, the group includes: **Albert F. Sommer,** New York City; **John M. Caylor** and **George A. Stiftinger,** Philadelphia; **Donald P. Moreland,** Cleveland; **Jack W. Larsen, Wilton A. Bass** and **Vendel W. Immel,** Detroit; **Thomas H. Jenkins, William H. John-**

son and **John L. Matter,** Chicago; and **Frank G. Fischer** and **Michael J. Joncich,** Los Angeles.

♦

The appointment of **A. R. Sedgebeer** as regional manager for California and Nevada has been announced by the lubricating equipment division of the Aro Equipment Corp., Bryan, O. Mr. Sedgebeer has been in the lubricating equipment field for the past 20 years.

♦

Frank P. Downey has been named divisional vice president and general manager of American Machine and Foundry Company's Pinspotters division.

♦

Telechron Department, General Electric Co., Ashland, Mass., has appointed **Donald E. Perry,** formerly commercial engineer, to assume the responsibilities of **W. F. Greenwood,** industrial sales manager, who has been recalled to active military service.

♦

Walter E. Palmer has been appointed regional manager for All-State Welding Alloys Co. Inc., to cover the territory of New Jersey, eastern Pennsylvania, Maryland, Delaware and the District of Columbia. He will be responsible for sales and service to the users of alloys and fluxes in his area and, as the contact man for the company's metallurgical resources and experimental laboratory, will provide technical assistance on problems involving welding, brazing, soldering, tinning and cutting of metals.

♦

Heller Brothers Co., Newark, N. J., has appointed **C. Fred Watkins** to the position of sales manager. He will make his headquarters at Newcomerstown, O.

♦

A. R. Booker has been appointed executive vice president and general manager of Electrofilm Corp., Los Angeles.

♦

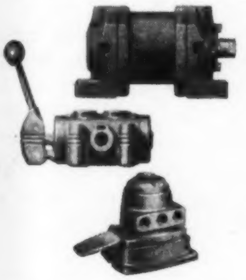
Mitchell A. Kapland, vice president, has been placed in charge of sales activities for all four divisions of Cummins-Chicago Corp., Chicago. He will supervise sales policies and programming for all branch offices, representatives and distributors of the portable tool division, the business machines division, the Fred W. Wappat division in Mayville, N. Y., and the government division. Mr. Kapland joined the organization in April, 1949 as general sales manager. In 1950

3 essentials

RIVETT offers to help you apply the correct air and hydraulic devices to your equipment!

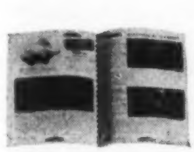
1 *Distributors at Your Service*

Rivett service is featured by the assistance of its factory trained distributors. These men are qualified from long experience to handle any air or hydraulic problem. Located in all principal cities, they can assist in laying out the circuit best suited to your operating requirements and recommend the correct equipment to provide long years of satisfactory operation.



2 *The Complete RIVETT Line*

Rivett can furnish the exact model valve, cylinder and power unit to meet individual requirements. For example—Rivett 4-Way Hydraulic Valves are offered in 50 models with 4 types of action—standard, spring return, spring centered and ball detent; 5 piston designs; 6 types of operation—hand, foot, cam, solenoid, oil and air pressures; 7 sizes— ¼", ⅜", ½", ¾", 1", 1¼" and 1½".



3 *Informative Literature*

The 100-page Rivett Catalog describes every detail of hydraulic and air valves, cylinders, and power units. It represents the most thorough presentation of hydraulic and air devices that long experience in this field can prepare. If you do not have the new Rivett Catalog in your file for reference and assistance, write for your copy today on company letterhead.

RIVETT LATHE & GRINDER, Inc.
Dept. MD9 Brighton 35, Boston, Mass.

WHEN YOU APPLY HYDRAULIC OR AIR POWER *Plan with* **RIVETT**

Air and Hydraulic Valves and Cylinders, Hydraulic Power Units.

he was elected vice president in charge of sales for the business machines division, which duties he performed until his recent promotion.

♦

The appointment of **Robert N. Nelson** as assistant sales manager, pneumatic division, is announced by Sundstrand Machine Tool Co., Rockford, Ill. Formerly sales engineer, Mr. Nelson will supervise sales and distribution activities on the company's line of air sanders for the automotive and general industrial fields.

♦

Formerly sales manager, **Ray L. Hampton** has been named vice president in charge of sales by Mosebach Electric & Supply Co., Pittsburgh, manufacturer of special brass and bronze castings for industrial use.

♦

Kennametal Inc., Latrobe, Pa., has appointed **A. D. Griffin** as engineer and representative in the San Francisco district, and **Conrad Seim** to the same position in the south Pacific district. A serviceman, **Frank Hull**, has been added to the central district office at Detroit.

♦

The appointment of **George H. Goecke** as sales engineer has been announced by Industrial Ovens Inc. He will work under the direction of **J. K. Gillett**, sales manager, and will use the Cleveland headquarters of the company as his base of operations.

♦

Harold G. Cheney has been appointed sales manager for the Westinghouse Electric Corp. electronic tube division. For the present he will retain his office in Bloomfield, N. J., and later will move to the division's headquarters plant, now under construction in Elmira, N. Y.

♦

Appointment of **Austin L. Hawk** as assistant manager of the western sales district, Manhattan rubber division of Raybestos-Manhattan Inc., has been announced. He is located at the district offices in Chicago, where for many years he has served in various capacities. Concurrently, announcement was made of the appointment of **S. V. V. Hoffman** as regional manager of the company's West Coast sales division for southern California, with headquarters in Los Angeles. **A. N. Johnston Jr.** has been appointed as assistant manager of the central sales district, with headquarters at Pittsburgh, and **D. H. Cottrille**, as West Virginia regional manager at Clarksburg, W. Va.

S A L E S
Notes

MANUFACTURER of variable speed control equipment, **Reeves Pulley Co.,** Columbus, Ind., has expanded its facilities on the West Coast. An assembly plant, together with sales and engineering offices, has been established in San Francisco, and a sales and engineering office has been opened in Los Angeles. These new facilities will enable customers to obtain faster delivery of variable speed drives and repair parts. R. G. Sullivan will be in charge of West Coast operations.

♦

Two offices of **Kennametal Inc.** were moved recently, the Cincinnati office, to 4873 Reading Rd., and the Minneapolis office, to 1016 Metropolitan Bldg.

♦

A modern four-story warehouse is being erected at East Pittsburgh by the **Westinghouse Electric Corp.** A number of devices will be employed to speed the flow of materials in and out of the building, such as specially designed pallet-handling cranes, floating shipping docks adjustable to various truck heights, belt conveyors and endless chains.

♦

The field service of **Conoflow Corp.,** Philadelphia, has been extended to embrace Houston, Tex., and Pittsburgh territories. The **M. N. Aitken Co.,** 5960 Kansas St., Houston, Tex., will represent Conoflow in Houston and the surrounding area, and the **Harold G. Jones Co.,** 502 Empire Bldg., will serve Pittsburgh, western Pennsylvania and northwestern West Virginia.

♦

The Weatherhead Co., Cleveland, manufacturer of tubing and pipe fittings, has appointed nine industrial distributors to carry complete lines of its various products. To handle the company's line of Ermeto steel and brass fittings are **B. H. Deacon Co. Inc.,** American & Huntingdon Sts., Philadelphia 33, Pa.; **Knox Inc.,** 33 Union St., East Walpole, Mass.; **Spence Tool & Rubber Co.,** 1530 North Adams St., Peoria 3, Ill.; and **P. T. Standard Parts Co.,** 88 Douglas St., Pontiac 16, Mich. New distributor for steel and brass fittings, reusable steel hose ends and industrial hose is **Diesel Injection Sales & Service,** 808 Union St., Norfolk 10, Va. The **Harry**

Cornelius Co., 1510 North Second St., Albuquerque, N. M., will handle the brass fittings line, reusable steel hose ends and industrial hose. In Akron and Massillon, O., **The Hardware & Supply Co.** has been appointed distributor for Ermeto and industrial tube and pipe fittings. Reusable steel hose ends and industrial hose will be carried by **Hydro Pneumatics Inc.,** 90 West St., New York 6, N. Y., and by Robins Rubber division of **A. K. Robins & Co. Inc.,** Candler Bldg., Baltimore 2, Md.

♦

A new 11,100 sq ft warehouse providing expanded facilities for servicing the Pacific Northwest is now being constructed for **Chain Belt Co.** in Portland, Ore. In addition to housing increased stocks of chain, sprockets, power transmission equipment, etc., the new building will contain the company's Portland district sales office.

♦

Metal Carbides Corp., Youngstown, O., has opened a new sales office, warehouse and service plant at 20485 Van Dyke, Detroit, Mich.

♦

American Cladmetals Co. has initiated a nation-wide expansion of its sales engineering organization. The New England area will now be served by **Wetherell Brothers,** 251 Albany St., Cambridge, Mass.; New York and Philadelphia metropolitan areas will be serviced by **Engineered Sales Co.,** 522 Morris Ave., Summit, N. J.; and the **William P. Knodel** organization, Kenmore, N. Y., will serve northern Pennsylvania and up-state New York.

♦

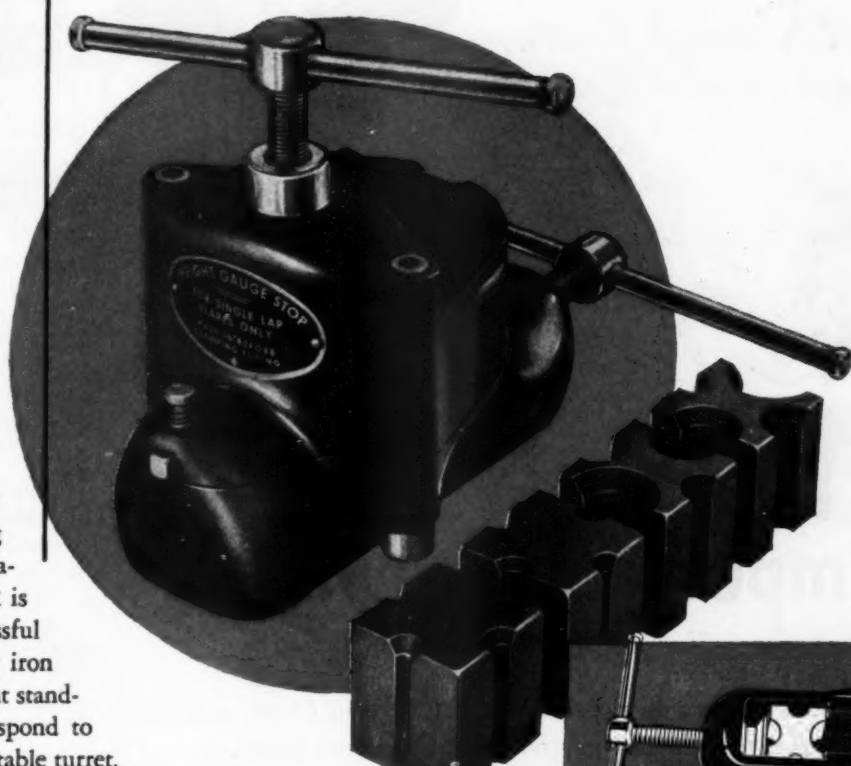
Manufacturer and designer of hydraulic machinery, **The Watson-Stillman Co.** of Roselle, N. J., has appointed the **Don W. Patterson Co.,** 2016 Rand Bldg., Buffalo, N. Y., as its exclusive sales representative in western New York State.

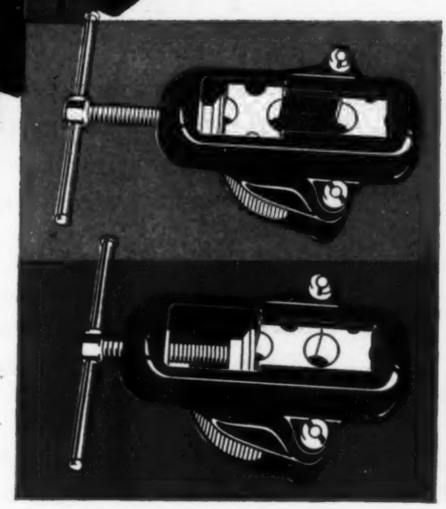
♦

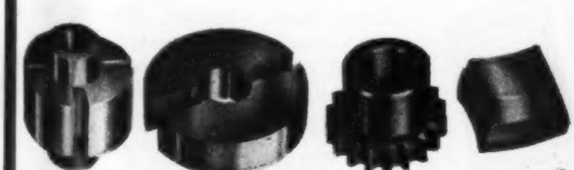
Chicago Steel Service Co., distributor of stainless and carbon steel, has moved into its new general offices and warehouse on Kildare Ave. at 45th St., Chicago, Ill. The new warehouse provides 120,000 sq ft of floor space and facilities include equipment to process orders for special shapes and sizes.

♦

Worthington Pump and Machinery Corp., Harrison, N. J., has opened a branch office at 506 Hall Bldg., Second and Locust Sts., in Harrisburg, Pa. A branch of the company's Philadelphia office, the new office will be under the direction of A. L. Mays.







Meetings

AND EXPOSITIONS

Sept. 24-26—
American Society of Mechanical Engineers. Petroleum mechanical engineering conference to be held at Hotel Mayo, Tulsa, Okla. C. E. Davies, 29 West 39th St., New York, N. Y., is secretary.

Sept. 25-28
American Society of Mechanical Engineers. Fall meeting to be held at Hotel Radisson, Minneapolis, Minn. C. E. Davies, 29 West 39th St., New York, N. Y., is secretary.

Oct. 1-4—
Association of Iron and Steel Engineers. Annual convention to be held at the Sherman Hotel, Chicago, Ill. T. J. Ess, Empire Bldg., Pittsburgh 22, Pa., is managing director.

Oct. 3-5—
Pressed Metal Institute will hold its National Meeting at the Drake Hotel, Chicago, Ill. Orrin B. Werntz, Pressed Metal Institute, 13210 Shaker Square, Cleveland, O., is managing director.

Oct. 3-6—
Society of Automotive Engineers. Aeronautic, Production Forum and Display meeting to be held at the Biltmore Hotel, Los Angeles, Calif. John A. C. Warner, 29 West 39th St., New York 18, N. Y. is secretary and general manager.

Oct. 13-17—
Packaging Machinery Manufacturers Institute. Nineteenth annual meeting to be held at the Mid Pines Club, Southern Pines, N. C. Boyd H. Redner is president.

Oct. 14-19—
American Society for Metals second annual meeting to be held at Hotel Book Cadillac, Detroit, Mich. Additional information may be obtained from society headquarters at the Hotel Book Cadillac, Detroit, Mich.

Oct. 15-19—
American Society for Metals Thirty-third annual metal show to be held at the Michigan State Fair Grounds, Detroit, Mich., under the sponsorship of the American Society for Metals; American Welding Society; Metals Branch, American Institute of Mining and Metallurgical Engineers; Society for Non-Destructive Testing. Additional information may

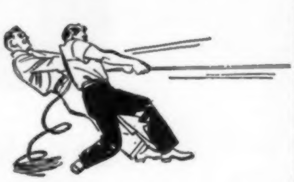
Here are the advantages of

CHASE PHOSPHOR BRONZES

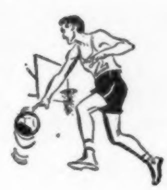
HIGH STRENGTH

HIGH-FATIGUE RESISTANCE

GOOD DUCTILITY



GREAT RESILIENCY



EXCELLENT CORROSION RESISTANCE

CHASE PHOSPHOR BRONZES are hard working alloys that stand up under tough production assignments.

These tin-alloy bronzes are extremely versatile. You'll find one alloy suited for such functions as bearings, fuse clips, spring contacts and springs. Others will do a superior job in diaphragms, screw machine products, gears, spindles, valve parts and similar products.

Chase Phosphor Bronzes are made in Rod, Strip and Wire. Each is subject to the careful scrutiny of Chase metallurgists and engineers in order to maintain Chase standards for surface finish and the requisite internal characteristics.

Fill in and mail the coupon below for free folder giving further information about the properties of Chase Phosphor Bronzes.

FREE FOLDER—Mail the coupon for folder giving tables of properties (hardness, tensile, fabrication, physical) as well as uses and forms.

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Boston	Detroit	Minneapolis	Providence	
Chicago	Houston†	Newark	Rochester†	(†sales office only)
Cincinnati	Indianapolis	New Orleans	St. Louis	

CHASE 75th ANNIVERSARY 1876 - 1951

be obtained from society headquarters, National Metal Congress & Exposition, 7301 Euclid Ave., Cleveland 3, O.

Oct. 22-24—
National Electronics Conference. Seventh annual conference to be held at the Edgewater Beach Hotel, Chicago, Ill., under the sponsorship of the American Institute of Electrical Engineers, the Institute of Radio Engineers, Illinois Institute of Technology, Northwestern University, and the University of Illinois, with participation by the University of Wisconsin and the Society of Motion Picture and Television Engineers.

Oct. 22-24—
American Standards Association. Thirty-third annual meeting and second annual national standardization conference to be held at the Waldorf-Astoria Hotel, New York, N. Y. Vice-Admiral George F. Hussey Jr., 70 East 45th St., New York 17, N. Y. is managing director.

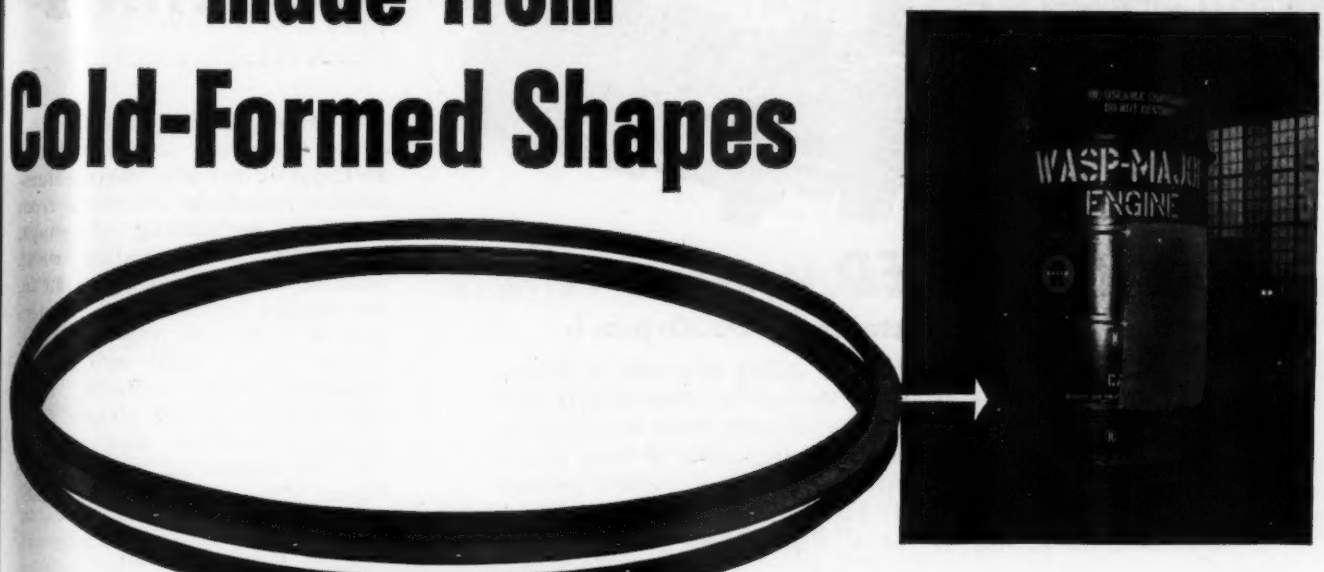
Oct. 29-30—
Society of Automotive Engineers. Diesel engine meeting to be held at the Drake Hotel, Chicago, Ill. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Oct 29-31—
American Gear Manufacturers Association. Semi-annual meeting to be held at the Edgewater Beach Hotel, Chicago, Ill. Newbold C. Goin, Empire Building, Pittsburgh 22, Pa., is executive secretary.

Oct. 29-31—
Society of Automotive Engineers. Transportation meeting to be held at the Knickerbocker Hotel, Chicago, Ill. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Nov. 8-9—
National Conference on Industrial Hydraulics. Seventh annual meeting to be held in Sherman Hotel, Chicago, Ill. Sponsors are the Graduate School of Illinois Institute of Technology and Armour Research Foundation of Illinois Institute of Technology. Co-operating societies are the local sections and chapters of American Society of Civil Engineers, American Society of Mechanical Engineers, Society of Automotive Engineers, American Society of Lubricating Engineers, American Institute of Chemical Engineers, Institute of Aeronautical Sciences, American Society of Agricultural Engineers, Illinois Society of Professional Engineers, and Western Society of Engineers.

Parts for Aircraft Engine Containers made from Cold-Formed Shapes



The two cold-formed shapes shown above are used as supports for containers which protect aircraft engines from dirt and moisture during shipment and storage. The circular shape is used in containers for radial-type engines, and the rectangular shape is used in containers for jet engines. We make each shape on a rolling machine, using ¼-in. steel, and supply them to the Rheem Mfg. Co. bent to shape, accurately punched, and welded.

Hardly a day passes but that someone comes up with a new use for Bethlehem Cold-Formed Shapes. In addition to supports for aircraft engine containers, waterways for radiant baseboards, side-plate sections for refrigerator cars, hatch covers for sea-going vessels, channels for telephone equipment, are just a few among a large number of recent new uses.

Bethlehem Cold-Formed Shapes are regular or irregular shapes formed cold from strip, sheet, bar or plate steel. They are uniform in thickness, and their surface is relatively free from scale.

They have an excellent strength-to-weight ratio. Our shop is equipped to turn them out on presses, brakes or rolls in gages from 5 to 24, inclusive.

Ask the nearest Bethlehem sales office to send you a copy of a new two-color booklet about Bethlehem Cold-Formed Shapes.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

★ BETHLEHEM STEEL ★

New Machines

Business Equipment

COPYING MACHINE: Low-cost Model 20 Copyflex machine, for medium-volume production of prints from tracings, engineering drawings, etc. Offers 46-in. printing width with exposure speeds up to 95 in. per minute. Requires only connection to a 60-cycle, 115-v a-c line. Copies may be made on Copyflex sensitized paper, acetates, films and cloths. Operator merely feeds sensitized medium into machine with the translucent original to be copied. *Charles Bruning Co. Inc., New York, N. Y.*

Communication

PORTABLE RADIOPHONE: Incorporates adjustable squelch to reduce annoyance of tube and circuit noises normally encountered in an F. M. receiver in absence of signal. Squelch control provides normal operating range of no-squelch up to 25 to 50-db noise reduction. Audio distortion resulting from use in fringe areas is eliminated. Available with wet or dry cell power supplied for operation in either 25-50 megacycle or 152-174 megacycle bands. *Motorola, Communications and Electronics Div., Chicago, Ill.*

Heating and Ventilating

AIR CONDITIONER: Capacities, 3, 5 and 7½ ton. Self-contained unit designed to save floor space and to cut service and maintenance to a minimum. Spring mounting contributes to quiet operation. Semi hermetic compressor requires little servicing. Designed for use in stores, offices, apartments, factory spot installations, laboratories and drafting rooms. *The Trane Co., La Crosse, Wis.*

Maintenance

BATTERY CHARGER: Automatic motor-generator type unit designed for shelf mounting. For charging batteries in industrial lift trucks. Accommodates lead-acid batteries of 6-19 cells and nickel-iron-alkaline batteries of 10-30 cells. Weight, 190 lb. Length 23$\frac{3}{16}$ in., height 10¾ in., 14 in. deep. Voltage, based on number of battery cells, and current, based on amp-hr battery ratings, are adjustable. Includes automatic disconnect and opening of charging circuit in case of power interruption, automatic restart on re-

sumption of power supply, automatic control of charging rate under modified constant voltage charging system, and automatic shut-down when battery is charged. Single-circuit equipment operates on 3-phase, 60-cycle a-c power. *General Electric Co., Schenectady, N. Y.*

FLOOR MACHINES: Disk type units available in 12, 14, 16 and 19-in. sizes for all types of floor maintenance operations. Powered by capacitor type motors for maximum operating efficiency. *Multi-Clean Products Inc., St. Paul, Minn.*

Manufacturing Equipment

RADIAL DRILL: Radius, 4 ft; capacity, 1¼ in. in mild steel. Accurate radial drilling machine has 9-in. column, saddle mounted on needle roller bearings. Drive is from a 2-hp constant-speed reversing motor. Has nine spindle speeds. Quick hand traverse, fine hand feed and automatic feed to spindle provided. Rigid or swivel type table. *British Industries Corp., International Machinery Div., New York, N. Y.*

PUNCH PRESSES: Variable-speed, 5-ton power presses in two models. With ram speeds suitable for deep drawing, piercing and blanking operations. Includes 18-in. diameter, 110-lb flywheel. Ram speeds variable from 95 to 280 strokes per minute by adjusting ¾-in. to 2½-in. diameter of motor pulley. Features include one-piece, 1⅛-in. crankshaft, 1-in. diameter clutch drive dog built into clutch collar, switch for changing from single to repeat operation instantly, and 12¾-in. throat. *Kenco Manufacturing Co., Los Angeles, Calif.*

SPRING COILER: Makes torsion, compression, extension and tapered springs—coiled either right or left hand without changing arbors. Handles wire stock from 0.005 to 0.125-in. Springs can be made with or without initial tension and with open or closed ends. Unit has three wire guides, three wire feed rolls and two coiling points. Size, 8 by 14 in. *Perkins Machine and Gear Co., West Springfield, Mass.*

SPOT WELDER: Three-phase unit with electrode force adjustable up to 23,000 lb and rating of 400 KVA. Meets requirements of Air Force-Navy Aeronautical specifications MIL-6860 and MIL-6858. Spot welds two thicknesses of ¼-in. aluminum alloy on heavy production basis. Features frictionless diaphragm pneumatic pressure system, adjustable wave shape, and improved current conductance achieved by adaptation of solid electrolytic copper

bars with sliding silver contacts at each terminal. Short-circuit tip-to-tip current is 225,000 secondary amp. Three-phase system balances load on supply facilities at power factor of 85 per cent minimum. *Sciaky Bros. Inc., Chicago, Ill.*

TAPPING MACHINE: Unit for speeding up tapping of radial holes. Manually loaded and started, machine automatically clamps part by means of air cylinder. Holes tapped simultaneously and part automatically unclamped. Output, approximately 480 pieces per hour. *Govro-Nelson Co., Detroit, Mich.*

SURFACE FINISHING MACHINE: Model 203, with vacuum chuck, holds items made of brass, copper, silver, plastic, aluminum, wood and other nonmagnetic materials. Horizontal, electro-hydraulic unit has moving work table consisting of perforated plate mounted over sealed air space which is connected to vacuum pump through four-way spring-return foot valve. Working area 38 by 36 in. Perforated plate covered by rubber mat. Table moves both in and out and sideways, with stroke adjustable from $\frac{3}{4}$ to 36 in. and $\frac{1}{2}$ to $1\frac{3}{4}$ in., respectively. Supplied with 5, $7\frac{1}{2}$, 10 or 15-hp motors. *Clair Manufacturing Co., Olean, N. Y.*

RECTIFIER WELDERS: Arc drive control to produce electrical transient characteristics desirable for certain welding operations. Available on Type RA selenium rectifier welders. Permits adjustment of arc characteristic of welder to suit particular job. Operates automatically and instantaneously to provide extra surge of welding current at moment arc becomes shortened. Eliminates overshoots and undershoots of current. *Westinghouse Electric Corp., Pittsburgh, Pa.*

SPRAYER: For use in spraying high solid content lacquer, synthetic and similar material at elevated temperatures. Requires less thinner and produces faster, more uniform finish equal to two or more coats of cold material. In capacities from 8 to 250 gal per hour output in nonrecirculating and recirculating types. Features include easy cleaning and accessibility for adjustments, minimum temperature drop and fast heating. *Reliable Products Mfg. Co. Inc., Brooklyn, N. Y.*

METAL SPRAYING MACHINE: Model B Spraywelder powder metallizing unit. Applies uniform overlays of hard facing alloys using metallizing procedures and subsequently bonds overlay to base metal. Can also be used to apply metal powder materials such as copper, brass,

stainless, aluminum and zinc. New features include: lighter weight, greater capacity air filter, more positive air and powder control valves, new trigger mechanism, increased cooling chamber in head and locked feed mechanism on carburetor. *Wall Colmonoy Corp., Detroit, Mich.*

GRINDERS: Four Model B800 series grinders feature improved accuracy standards, greater capacities, heavier construction, improved lubrication system and easier operation. Specifications include: swing over table, 8¼-in.; distance between centers of head and tail stocks, 18¾-in.; working surface, 5¼ by 25¼-in. All shafts ball-bearing mounted. Saddle ways have automatic compensation for wear; wheel head swivels 360 degrees. Cabinet stand base dimensions, 18 by 18 in. *K. O. Lee Co., Aberdeen, S. D.*

MOLDING MACHINE: Pushbutton control, jolt-squeeze-strip Model No. 2364 for production of large copes and drags. Operates on standard 80 psi air; has squeeze capacity of 80,000 lb and jolt capacity of 4000 lb. Squeeze cylinder diameter, 36 in.; pattern draw, 14 in.; squeeze piston stroke, 14 in. Flask space from 38 to 54 in., left to right, and from 32 to 50 in., front to back. Unit furnished complete, designed for recessing 50 in. below floor level; extends 116 in. above floor. *SPO Inc., Cleveland, O.*

PORTABLE RIVETER: Unit for driving rivets with hydraulic pressure, utilizing squeezing action. Delivers 60,000-lb thrust through hydraulic ram; drives ⅝-in. cold rivets. Riveting cycle takes 2½ seconds. Unit is relatively quiet and requires little maintenance. *Manco Manufacturing Co., Bradley, Ill.*

Materials Handling Equipment

CONTINUOUS CONVEYER-FEEDER: Variable-speed unit handles small forgings, castings, stampings and machined parts during processing operations. Custom fabricated to meet individual requirements; available with variety of belt widths. Guaranteed against jamming and bridging. *May-Fran Engineering Inc., Cleveland, O.*

WORKING HEIGHT LIFTER: Keeps work at convenient height. Lifting, stopping and lowering of load are controlled by remote pedal switches. Mechanism consists of 1/3-hp, 115-v, 60-cycle a-c motor connected to a piston pump which delivers oil under pressure to hydraulic lifting ram. Pan type platform lowers to floor. Capacity, 4000 lb; lifting height, 42 in.; overall height, 72

in.; platform lengths, 36, 42, 48 and 54 in.; platform widths, 32 or 38 in. *Lewis-Shepard Products Inc., Watertown, Mass.*

BELT CONVEYOR: For handling goods during assembly, inspection, sorting, etc. Specifications: length, from 10 to 60 ft; width, 10, 12, 16, 18 or 20-in. belts; height, from 21 to 40 in.; belt speed, from 5 to 100 fpm, fixed or variable speed; belt direction, one-way or reversible; motor, 1/3-hp, 1 or 3 phase. *Rapids-Standard Co. Inc., Grand Rapids, Mich.*

STOKERS: Permit easy filling of hoppers and avoid interference with boiler flue cleaning doors. Hopper is fully open and sloping on top. Two sizes available for use in warm air, steam or hot water systems and industrial applications. Metering type worm feeds coal in "unpacked" condition. Automatically regulated, air is supplied by fan. *Iron Fireman, Cleveland, O.*

ELECTRIC LIFT TRUCK: Equipped with 18-in. lifting platform; can be furnished in 6, 7, 9 and 11-in. lowered heights to engage conventional platforms. Battery-operated unit has spring-mounted stabilizing casters on each side. Features three-way operating positions. Also available in conventional widths. *Market Forge Co., Everett, Mass.*

TELESCOPIC PORTABLE CONVEYOR: Roller type unit for conveying objects not having rigid, flat bottoms. All steel construction. Adjustable brake-lock holds conveyor securely in position. Supplied in 12 and 18 in. widths; nine lengths which extend to maximum of 30 ft. *The Wilkie Co., Philadelphia, Pa.*

FORK LIFT TRUCK: Capacity, 4000 lb. Model YT-40 has dual wheels on steering trunnion. Gear ratio in steering mechanism reduced from 31 to 1 to 20.7 to 1. Tire size reduced to 6.00 x 9 to provide interchange with tires on Model 20. *Hyster Co., Portland, Ore.*

STACKER: Specially made Jackstacker for handling tote bins, tightly sealed containers for handling, shipping and storing bulk materials. Telescopic and nontelescopic models with capacity for 4000-lb loads up to 48 in. long. *Lewis-Shepard Products Inc., Watertown, Mass.*

PLATFORM TYPE POWER TRUCK: Two-section platform with divided forward trail axle. Two parallel frames reinforced and welded to truck body; platforms joined at rear ends, enabling them to be raised or lowered simultaneously. Platforms are of heavy gage steel

Big New MB Shaker!

...rated at

2500 POUNDS

force

20-inch shake table!

15g at 100 lb table load!

Electrically interlocked control!

No foundation needed!

Here's heavy duty capacity for your vibration testing to military specification MIL-E-5272 and 41065-B

Vibration testing reveals *in advance* how your products will behave in service. It's a "must" for military equipment. This new MB model C-25 shaker, one of the largest developed, provides large "brute force" for meeting military vibration testing specifications. Rated at 2500 pounds continuous vector force, it has capacity to produce 15g with 100 lb table load or 20g with 58 lb table load.

An electromagnetic exciter, MB model C-25 features accurate, continuous, easy control of force and frequency. Electrically interlocking controls assure proper operation.

Whether your own vibration testing requirements are of large order or small, you can get the answer to your problem at MB. Models start at 10 pounds force output. Resonant beams for special problems also available.

Make MB *your* headquarters for help and advice on vibration problems. You'll save yourself time and work. *Write for new Bulletin* No. 1-VE-3 *on vibration exciters.*

MB's C-25 shaker with control panel. Available with built-in meter to read directly acceleration, velocity or displacement.

THE MB MANUFACTURING COMPANY, Inc.

1060 STATE STREET, NEW HAVEN 11, CONN.

PRODUCTS AND EQUIPMENT TO CONTROL VIBRATION . . . TO MEASURE IT . . . TO REPRODUCE IT

plate with deep flanges. In lowered position flanges come down at sides of wheel frames. Platform size: $6\frac{3}{4}$ in. wide, 63 in. long; 14 in. apart. Lowered, platforms are $10\frac{1}{2}$ in. above floor, raised, 15 in. All-electric or gas-electric powered. Capacities, 2000, 4000 and 6000 lb. *Elwell-Parker Electric Co., Cleveland, O.*

Plant Equipment

AIR GRINDER: For hand grinding in snagging, trimming, smoothing, etc. Features include: overspeed safety coupling, multiple exhaust system and reduced exhaust noise, safe-carrying grip type handle. Rubber-faced throttle valve unaffected by oil or moisture. Available for 8, 6 or 5-in. wheels, running at respective motor speeds of 3100, 4100 and 4500 rpm. Overall length, $24\frac{5}{8}$ in. with straight handle, $22\frac{1}{2}$ in. with grip handle; maximum side-to-center distance, $2\frac{5}{16}$ in.; weight, $16\frac{1}{2}$ lb with guard. *Ingersoll-Rand Co., New York, N. Y.*

NOISELESS AIR VIBRATOR: Type AC unit for applications where noise is major factor. Used in packaging foodstuffs, chemicals, etc. Reciprocating action of hard chrome-plated piston develops vibrating action. Features variable vibration speed and vibration intensity. Size: $6\frac{1}{2}$ by $1\frac{1}{2}$ in.; weight, 2 lb, 11 oz. *Cleveland Vibrator Co., Cleveland, O.*

POWER SUPPLIES: High voltage d-c RF type units available in variable and fixed voltage outputs from 1 to 60 kv and current ranges from 50 microamperes to 2 milliamperes. Features include: high safety factor, compactness, ease of operation. For applications in electrostatic paint spraying, dust precipitation installations and transcription recording, insulation testing and laboratory research equipment. *Inductograph Products Inc., Brookfield, Conn.*

CONDENSATE RETURN PUMP: Vertical unit for applications up to 8000 sq ft EDR at 20 psi. Handles water to 210 F without vapor lock. For installations where return piping is close to floor level. Can also be installed in shallow pit without danger of flooding motor. Complete assembly includes pump, 10 or 15-gal, cast iron or steel receiver, enclosed float switch, single or three-phase 1750-rpm motor. *Roy E. Roth Co., Rock Island, Ill.*

ELECTROMAGNETIC HAMMER DRILL: Model 17-RO for drilling holes in concrete, brick and stone. Features include: automatic rotation, high speed, elimination of manual turn-